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Vol. CX.] [Part I.

Journal of the Royal Statistical Society

PART I, 1947

PROCEEDINGS OF THE FIRST ORDINARY MEETING OF THE SESSION, 1946–47, HELD ON NOVEMBER 27TH, 1946, THE PRESIDENT, THE RT. HON. LORD WOOLTON, P.C., C.H., IN THE CHAIR.

BEFORE the reading of the paper the PRESIDENT said that he had a particularly pleasing duty to perform that evening. Under the terms of the award of the Guy Medal in Gold the Council was empowered to make this, its highest mark of distinction, only at intervals of five years, unless by special resolution it was decided that an award should be considered at an intermediate date. Last year the award was made to Professor Major Greenwood, and the next award therefore was not due to be considered until 1950. But that was a long way off; happily there was in the ascendant another statistical star, and the Council was commendably impatient at the delay of five years. It had therefore passed a special resolution and, as a result, had decided unanimously to offer a medal in gold to Professor R. A. Fisher.

The Society had a habit, for which he was personally grateful, of selecting as its President either somebody who was distinguished as a statistician, and about whom there was evidence of distinction, or someone who was somewhat ambiguously described as a "distinguished outsider"—that is, someone about whose work and value there was no statistical evidence whatever. He was an outsider, and it would be nothing short of presumptuous for him to attempt to speak about Professor Fisher's work. Fortunately it was quite unnecessary for him or for anyone else to speak of it, for both his work and his name had been known for many years throughout the world. The Council's last report stated:

> "He is pre-eminent for his distinguished contributions to the theory and practice of statistics, and to the design of experiments, contributions which have had a profound effect upon scientific method in many fields."

Professor Fisher was an Englishman. In many fields in this country, fortunately, the distinguished merit of people of other nations was recognized, and it was a matter of considerable satisfaction that Professor Fisher, whose name was held in honour in this country—and nowhere more than in the narrow and eclectic circle of the Society—should be recognized.

It was with great pleasure that on behalf of the Fellows he offered to Professor Fisher the Society's highest award, the Guy Medal in Gold.

Professor FISHER, in acknowledgment, said that he accepted this medal as a noble gift from most generous friends. He supposed the profit motive was not regarded in these captious and inhibited times with the same respect as it was by the founders of the Society, but the early awards of gold medals by learned societies to their members and others must always have had in view another motive. They were never regarded merely as bullion, equivalent in cash at £4 or £10 to the ounce. The founders of these medals must have thought on some such lines as these: that there is another motive for work and perhaps it can be expressed in very few words, that is, to gain the esteem and appreciation and, at best, the gratitude of one's fellow workers, having in view the same object of the advancement of human knowledge. Perhaps these objects were put into gold with the thought that the same energy and talents devoted to the profit motive would have been rewarded perhaps amply, but were rewarded in paper, and in paper of an ever diminishing purchasing power, whereas gold maintained its value and even appreciated in value, and in that resembled and symbolized perfect esteem, appreciation and gratitude.

The PRESIDENT then called upon Professor P. SARGANT FLORENCE to read his paper.

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THE STATISTICAL ANALYSIS OF JOINT STOCK COMPANY CONTROL.

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1. *In Search of the Entrepreneur and His Policy*

IN the recent literature of Economics increasing attention is being paid to the policy of the entrepreneur in general as a factor determining the degree of economic activity, for instance, investment. At the same time the policy of any one entrepreneur is, with the disclosure of the size of firms and business units relative to the industry,* coming to be thought of greater significance. Prices are no longer assumed as competitively determined by the market, irrespective of any one entrepreneur's price or output policy, and may often be taken, to quote Mr. Gardiner Means, as "administered."† Just as the internal structure of an industry—its scope, location and the size of its constituent plants—are mainly determined by the policy of the firms composing that industry; so now, it is held, the more purely economic issue of *terms of exchange*—the amounts of various goods and services (capital and consumers) exchanged at various prices—is largely determined by individual large-scale entrepreneurs.

Statistical research has recently turned to *industrial* problems of location policy,‡ and with the great progress made in the Census of Production analysis since 1930 it is possible to discuss in statistical terms the inter-relation of location and the size of establishments. Attention should now also be drawn to statistical research (and the great possibilities of more research) into economic problems, such as the industrial firm's marketing or its financial policy in dealing with the outside world to which it sells, or from which its material and financial supplies are obtained. The direction such policy takes may be linked up with the firm's management and administrative functioning. The issue is, in short, how far varieties in the economic policy of industrial firms can be related to varieties in their control.

With the growth of consumer's co-operation and the advent of nationalization in mining, transport and probably some manufacturing industries, the question of how policy will be affected has become of prime importance. Will nationalization or co-operative production be correlated, for instance, with more or with less investment per worker than would otherwise occur, and thus probably with more, or with less, productivity per man-hour?

Investment per worker and the disposal of profit or surplus are measurable statistically. In America, controversy over the Undistributed Profits Tax§ and the use of accounts and especially operating ratios|| as a tool in good administration have disclosed a wide divergency between the investment policies of different firms. At one and the same time and in one and the same industry, some firms will pursue "sound" policies of keeping assets liquid, other firms will be investing heavily in fixed plant.

If differences in policy can thus be statistically measured, the question before us is whether statistical measurement is also possible of different types of control with which to correlate or at least associate types of policy. It might thus be found what particular type of control was related to a policy of expansion involving full employment and high exports.

* See Leak and Maizels, "The Structure of British Industry," *J.R.S.S.*, 1945, Parts I and II.

† U.S. Senate, 74th Congress, 1st Session, Document 13.

‡ Florence, "Economic Research and Industrial Policy," *Economic Journal*, December, 1937. "The Selection of Industries Suitable for Dispersion into Rural Areas," *J.R.S.S.*, 1944, Part II.

§ In a book with this title, Buehler quotes (p. 74): "The frequency distribution of some 79,625 of the larger American corporations according as they distributed in cash 0 per cent. to over 90 per cent. of their net book profits for the year 1922."

|| Wall and Donning, *Ratio Analysis of Financial Statements*. Guthmann, *Analysis of Financial Statements*. Bliss, *Financial and Operating Ratios*.

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The formal differences between capitalist, State and co-operative control are familiar enough, and need not detain us. The real distinction between them is usually presumed to be that the capitalist controls by virtue of his ownership and risking of the capital invested, while those in control under State and co-operative auspices are essentially administrators of other people's property and thus, if honest, likely to be cautious and unenterprising. Modern developments within the capitalist system since classical economics laid the foundation of our apparatus of thought have, however, blurred this distinction. The public joint stock company in particular has kept economists guessing as to the real seat of its control. Who, it may be and has been asked, among the owners of shares paid by dividends and the managers paid by salary is the entrepreneur paid by profit? Does control still go with risk, or is there no "Golden Rule"* left? Deduction from such a perplexing situation as to the policy likely to be pursued can obviously not be relied upon. It is necessary to observe and measure the facts statistically. Some statistical association of variety of control with variety of investment policy has already been measured: two tentative conclusions may be cited.

(1) *Consumers' co-operative control tends to be cautious in policy and to keep assets liquid; it invests in fixed capital to a less degree than Joint Stock Companies.*

The statistical evidence for this statement appears in co-operative balance sheets, and is discussed at length in Chapters 6 and 25 of Carr-Saunders, Florence and Peers' *Consumers' Co-operation in Great Britain*, especially the revised edition, 1942.

(2) *The original sole-trader "entrepreneur" tended to re-invest more than the average joint stock company to-day.*

Lavington† reviews the older established manufactures of Britain one after another. In cotton weaving, "as accumulating profit increases his resources" a small weaver "multiplies the number of his looms." In the Belfast linen industry "the great bulk (of capital) has apparently been drawn from profits." In the boot trade "most of the large businesses have started in a very small way and gradually have been extended as the owners' means have increased." "In the woollen and worsted industries the practice of obtaining capital by the public sale of securities has made no great progress . . . The heavy iron and steel trades in the North of England originated as private undertakings and grew mainly by the re-investment of profits." Even in cotton spinning where "the use of the public joint stock company as a means of obtaining capital for the creation of new undertakings is especially marked," the initial capital which a new undertaking obtained in this way in the years before 1914 was comparatively small, perhaps £10,000 on the average. Much was obtained by trade credit and bank loans, and was repaid out of profits as the company gradually grew to its full strength.

Historical research, although there has been all too little on this subject, suggests that the entrepreneur owner-manager both re-employed the bulk of his profits, i.e. put them to reserves, and re-invested them, i.e. put the reserves into his own trade. Can any objective evidence be cited of the policy on those heads of a control more divorced from ownership?

The proportion of profit undistributed and re-employed by a large sample of English joint stock companies is calculated annually by the *Economist*. Between 1924 and 1935 the proportion varied between 5·5 and 24·0 per cent., with an average of about 18 per cent. Company savings have been viewed authoritatively with some satisfaction,‡ but it is not likely in face of the evidence just cited to have reached the proportion of profit re-employed by the Victorian entrepreneur. There is evidence that American companies put back a higher proportion than English. Epstein shows that in the five prosperous years 1924–28, over two thousand large manufacturing corporations reserved 45, 50, 45, 28 and 35 per cent.,§ while Paton shows that smaller corporations reserved 43 per cent. of profits, on the average, during 1927–29.‖ In the depression years starting 1930, however, dividends were declared in excess of profits, and even American corporations do not probably, over an average of years, reserve more than the classical entrepreneur.

* D. H. Robertson, *The Control of Industry*.
† *The English Capital Market*, 1921, p. 278.
‡ *Colwyn Committee on National Debt and Taxation*, 51.
§ *Industrial Profits in the U.S.*, p. 24.
‖ *Corporate Profits*, p. 6.

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Enquiries into the "co-variation" of variety of control and variety of policy should be extended and intensified. The Joint Stock Company is to-day the leading form of industrial undertaking in "free" societies. But the precise seat of control differs in different Joint Stock Companies, and with such differences, policy will probably differ in important respects, possibly all the way from restrictionism to full enterprise. The first task is therefore to analyse companies so as to find the precise interest which is in control.

The line of enquiry that follows here is intended as a pilot investigation, to plumb the hidden reefs putting any useful statistical investigation into jeopardy, and to make a preliminary survey of the types of control likely to be encountered. It is only one step in the investigation—a step which is not too difficult, since it does not require questioning of those actually engaged in business, nor yet questionnaires. Once this first step of analysing publicly available sources of information is achieved, a firm foothold is obtained for the more difficult steps requiring tact, patience, and some inside knowledge. These steps may interpret the results of the first step or add further information, and would include enquiries into the past history of the company, into its transactions and the key personalities involved, and examination of its accounts from time to time.

The question of the effect of actual types of control of industry upon industrial policy is so fundamental that no apology is needed for a gradual step-by-step approach to its investigation. Attempts to achieve and consolidate each step are worth separate detailed publication and discussion.

2. *The Analysis of Joint Stock Distribution*

Enquiries into American stock companies, i.e. Corporations, particularly that of Berle and Means,* suggest that there are wide divergencies in the seat of control. Some companies, where the issued capital, or most of it, is privately owned, seem to reproduce the classic capitalist situation of control by an owner-manager entrepreneur. The control of others is hardly distinguishable from the administrative type associated with co-operative or nationalized undertakings. It is the burden of Berle and Means' conclusions that in almost half (44 per cent.) of the 200 largest American non-financial corporations (controlling approximately 49 per cent. of all corporative wealth), the divorce of management from ownership is practically complete, and control is entirely administrative. But British as well as American enquiries suggest that between the autocratic quasi-entrepreneur type of company control and the bureaucratic quasi-administrative type lies a control situation that is peculiar to the joint stock company.

Voting stock in the larger companies is usually distributed over a great number of shareholders. Parkinson gives the precise figures for ten well-known British Companies in 1932.† They ranged from 4,520 in Watney, Combe, Reid to 94,690 in Imperial Tobacco and 124,960 in Imperial Chemicals. Most company shareholders hold shares in other companies as well, and are too ignorant or too busy or too idle to take much interest in control—as almost 100 per cent. absence from shareholders' meetings amply testify. Moreover, those already in control ask for proxies (postage at the company's expense) from absentee shareholders, and proxies in the pocket of the Chairman usually outweigh the voting strength that does attend meetings.

It is possible therefore for a group of shareholders to control policy even though they own only a minority, even as little as 20 per cent. of the voting capital.‡ This situation may be called one of *partial divorce of control from ownership*, since only that part of the owners who do *not* belong to the coherent oligarchic group of holders are divorced from control.

The controlling group must be small, say twenty, in order to attain cohesion, but the mere statistical fact that 20 shareholders own at least 20 per cent. of the voting capital is not enough to establish the fact of this "minority owners' control." Further particulars must be shown, and, in my view, at least four qualifying tests passed. The largest shareholders must be such that (1) among a sufficient number of them there is likely to form a coherent group, and (2) no equally

* *The Modern Corporation and Private Property*. For a similar enquiry in Canada, see *Royal Commission on Price Spreads*.

† *Scientific Investment*, 1932, p. 4. The list reappears in the *Report of the Board of Trade Committee on Company Law Amendment*, 1945, par. 127.

‡ See Prof. L. S. Penrose. "Elementary Statistics of Majority Voting," *J. R. Stat. Soc.*, 1946, Part I, p. 54. "The important statistical fact which emerges . . . is the very high degree of control exercised by a comparatively small resolute group when the indifferent population is very numerous".

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potent opposition group is likely to form. The group should (3) be likely to be interested in control. An industrial company, for instance, is more likely than an individual to hold a large block of shares for purposes of business control, rather than mere income from dividends. Finally (4) it should be shown that some of the shareholders in the group do in fact exercise control as directors or as administrative officers.

Berle and Means often had to classify the American corporations they studied into types of control according to press reports, "street knowledge" and other fragmentary evidence. In England there is a more official and more exact source of information. Every company must file a list of members and their shareholdings with the registrar of joint stock companies. This list is normally kept at Somerset House and is open to inspection; from these lists an exact statistical distribution of the size of holdings can be obtained. Symbols may be worked out to summarize all the relevant details without mentioning names. The symbols are given in Table I.

TABLE I.—*Symbols used in Joint Stock Analysis*

B = Bank.	N = Nominee Co.
C = Company.	P = Person.
I = Insurance Co.	T = Trust.
M = Nominee Co. (Bank).	S = Sundry.

a, b, c	=	Different names.
x	=	"another," not named.
1, 2, 3	=	Recurrence of same name.
*	=	Director.
†	=	Chairman or Vice-Chairman.
‡	=	Managing Director or Assistant.
Brackets	=	Recurrence of same Director, Chairman, etc., already listed.

The relevant information that is required is not the total distribution of the capital among shareholders in Joint Stock Companies, but the proportion of the capital with unconditional* voting rights held by the twenty or so shareholders holding the largest blocks of shares. Such a Joint Stock Analysis is given in Tables II, III, IV, V and VI, referring to English companies in 1935–36, together with information on assets obtained from the Stock Exchange Year Book.

This type of analysis reveals considerable information in response to the four tests for "oligarchic" minority owners' control.

(1) That the leading holders are likely to form a coherent body can be surmised from a family relation and an identity of name; i.e. the same *letter* occurring after P. In Company XIV (Table III) there are among the largest 20 shareholders six persons ("P") with the name "a" owning between them 31·0 per cent. of the voting power. Persons of different name may sometimes be found connected at other places in the record. Thus, in Company XVI (Table VI), members of the family Pb hold stock separately, but are also found to be holding stock jointly with members of the Pa and Pc family, and the interest of the two families can be connected.

(2) Lack of any potent opposition can be judged by the amounts of stock held by any small coherent group outside the apparently dominant group. If there is a steep "gradient" in the percentages of voting power of holdings as they get smaller, effective opposition is less likely from the smaller against the larger holders.

(3) Light is shed on the possible interests of leading shareholders by their differentiation by symbol into persons, and various sorts of companies such as banks, trusts, insurance and ordinary industrial companies. In Company XVII (Table V) companies number seven among the largest thirteen shareholders and own 26·9 per cent. of voting power.

(4) All directors' names are officially recorded. It is known also whether they hold the office of chairman, vice-chairman, manager, assistant-manager, etc. These directorships and administrative offices held by the leading personal shareholders are noted by symbol in the Tables. In the case of company shareholders, the note refers to directors of that company, and indicates an interlocking of shares and directorships (and of offices) between the company tabulated and the company holding its shares.

* e.g. exclusive of voting rights by preference shareholders if their dividends are in arrears.

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TABLE II.—*Percentages of Voting Power held by the* 20 *Largest Shareholders in Three Companies Showing Relatively* even *Distribution of Ownership*

Order.	Company XI.	%	Company XII.	%	Company XV.	%
1	Pa1‡	1·3	Ia	0·5	Ta1	1·7
2	Pb	1·1	Pa	0·4	Na	0·8
3	Pa2	0·7	Pb†	0·4	Ca	0·7
4	Pc	0·5	Tb	0·4	Cb	0·6
5	Pd	0·5	Na	0·4	Tb	0·5
6	Pe	0·4	Ma	0·3	Ta2	0·5
7	Na	0·4	Pc + Pd	0·3	M	0·4
8	Pf	0·4	Ib	0·2	Pa	0·4
9	Ia	0·4	Pe*	0·2	Ta3	0·4
10	Ca	0·3	Ta	0·2	Ia + x	0·3
11	Pg	0·3	Ia	0·2	Pb*	0·3
12	Nb	0·3	Pf	0·2	Pc	0·3
13	Ph	0·3	Pg + Ca	0·2	Pd1	0·3
14	Pi*	0·3	Tc	0·1	Ib	0·3
15	Ma	0·3	{Ph + Cb + Pi}	0·1	Pd2	0·3
16	Pk	0·3	Pk	0·1	Pe*	0·3
17	Nd	0·3	Pl	0·09	Ic	0·3
18	Ta	0·3	Pm	0·09	Tc	0·3
19	Pl	0·3	Pn	0·08	Id	0·2
20	Pm	0·2	Nb	0·08	Ta4	0·2

Summary:

Total of 1st 20 holdings	8·9%	4·5%	9·1%
Unconditional Voting Capital = 100% ..	£3,818,737	£6,215,194	£5,714,000
Total Issued Capital ..	£6,306,237	£6,215,197	£5,714,000
Debentures Issued ..	£2,250,000	None	None
Reserves (1935) ..	£973,609	£1,009,731	£676,000
Directors among 1st 20 shareholders	2	2	1
Total number of Directors	19	8	16

For explanation of symbols see Table I.

There is one main obstacle to the discovery of the true distribution of ownership in English companies, namely, the possibility that the registered shareholder may be a mere nominee of the true or beneficial owner. Such nominees may be companies, often subsidiaries of banks formed for the purpose, or they may be persons. In the latter case, these "dummy" nominees are not distinguishable in any list of shareholders from real owners.

The appointment of nominees, however, is not entirely fatal to all knowledge about the distribution of ownership control. The real beneficiary owner may adopt one of three plans. He may (*a*) assign all his shares to one nominee who has no one else's shares assigned to him, he may (*b*) assign them to a common nominee (e.g. a company) that has also others' shares assigned to it, or (*c*) he may assign them to several nominees. Plan (*a*) does not change the statistical distribution of shares over holders, though the identity of the holders is changed. But distribution is changed when the largest shareholdings are split up to conceal the concentration of votes. In this case, plan (*b*) would hardly be adopted, since it would increase the appearance of concentration, and in any case, if large owners joined in a common nominee (apart from a bank), it would be some evidence of possible coherence among them. Plan (*c*) (assignment to several nominees) is left as the main camouflage. If it is widely adopted, it results in the distribution of shares over holders

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TABLE III.—*Percentage of Voting Power held by* 20 *Largest Shareholders in Three Companies Showing Relatively* Concentrated *Ownership, much of it by Connected* Persons

Order.	Company III.	%	Company XIV.	%	Company XVIII.	%
1	Ma	29·2	Pa1	10·6	Pa1*‡†	1·9
2	Pa1‡†	5·2	Pb1‡	9·3	Pb1‡†	1·8
3	Pb1*	4·2	Pa2*	5·9	Pb1 (‡†), Pc1, Pd	1·8
4	Na	4·1	Pa3	4·4	Pb2 + Pb1	1·7
5	Pb2	2·5	Sa	3·6	Pe1 + Pe2	1·6
6	Pa2*	2·4	Pa4‡	3·2	Ta1 + Pf1	1·3
7	Ta	1·7	Pc1 + xx	3·1	Pa2†	1·4
8	Pa3*†	1·2	Pc2	2·9	Pb1(*) + Pd	1·4
9	Pb3*	1·1	Pd	2·6	Pg	1·3
10	Ba	1·1	Pb2	2·4	Ph1	0·9
11	Pa4*†	1·0	Pa5*	2·2	Ph2	0·9
12	Pa5*†	1·0	Ta1	2·0	Pa2 + Tb	0·9
13	Ca	0·9	Na	1·9	Pi, Pk, Pl	0·9
14	Pb4	0·6	Pb3	1·9	Ta2 + Pf2	0·9
15	Pc1	0·5	Pe + x	1·9	Pg2, Pg3, Pgi	0·8
16	Pb5	0·4	Pf1, Pf2, Pg	1·7	Pb2	0·8
17	Tb	0·4	Pb4‡	1·6	Pn	0·8
18	Pa6 + xx	0·4	Sb + Pe	1·5	Phi + Po	0·7
19	Pb5 + xx	0·2	Pa6	1·1	Ma	0·7
20	Pd	0·2	Ph1 + x	1·1	Pp, Pq, Pr	0·6

Summary:

Among 1st 20 holdings:			
Total for Pa's ..	11·2%	27·4%	4·1%
,, Pb's ..	10·2%	15·2%	7·5%
Total of 1st 20 holdings	58·3%	65·3%	23·1%
Unconditional Voting Capital = 100 ..	£1,125,000	£3,500,000	£2,960,298
Total Capital Issued	£9,505,000	£4,500,000	£4,498,534
Debentures	£1,700,000	£1,750,000	£715,000
Reserves (1935) ..	£1,700,000	£2,816,000	£2,225,000
Directors among 1st 20 holders	7	5	3
Total number of Directors	13	15	9

For explanation of symbols see Table I.

appearing more scattered than true ownership, but it will not give any false impression of concentration. Caution must therefore be exercised in declaring holdings in any company to be relatively evenly distributed, but appearances of concentration and relatively uneven distribution are not so likely to be deceptive.

3. *Findings of the Pilot Analysis*

The shareholdings in 20 of the 80 largest English trading companies have been analysed for 1936 by Mr. H. M. Davis and Dr. W. Baldamus under my supervision, in the manner set forth in Tables II to V. "Trading" covers companies in the iron, coal and steel, the breweries and distilleries, the shipping, and the industrial and commercial sections of the *Stock Exchange Year Book*. These twenty companies were selected at random subject (1) to the exclusion of the ten companies in which the distribution of holdings (though not the character of the holders) had already been given by Mr. Parkinson in his *Scientific Investment*, and (2) to representing as many different industries as possible.

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TABLE IV.—*Percentage of Voting Power held by the* 20 *Largest Shareholders in Three Companies Showing Relatively* Concentrated *Ownership, much of it in the hands of* One Company

Order.	Company VIII.	%	Company X.	%	Company XX.	%
1	Ta	18·2	B	16·2	Ta	25·8
2	Pa‡	3·1	Ca	12·9	Ca	8·1
3	Ia	2·7	Na	1·3	Ma	6·3
4	Tb	2·3	Pa	1·2	Mb1	5·4
5	Ca	2·3	Pb‡	1·1	Cb	3·2
6	Ib	1·4	Pc*	1·1	Tb	2·3
7	Cb	1·3	Pd	1·0	Mc	1·8
8	Tc1	1·2	Pe	0·9	Na	1·1
9	Pb	0·8	Pf1	0·8	Nb	0·9
10	Ma	0·7	Pg	0·6	Md	0·7
11	Ic	0·7	Ta	0·6	Me1	0·6
12	Tc2	0·6	Ph*	0·5	Te1	0·6
13	Pc	0·6	Nb	0·5	Nc	0·5
14	Pd	0·6	Pi	0·4	Mf	0·5
15	Na	0·5	Pf2	0·4	Mb2	0·5
16	Pe	0·5	Ia	0·3	Tc2	0·4
17	Cc	0·4	Tb	0·3	Td	0·4
18	Id	0·4	Pk	0·3	Mg	0·4
19	Td	0·4	Pg2	0·3	Mh	0·3
20	Pf	0·3	Pl	0·3	Te	0·3

Summary:

Percentage in one or two Holding Companies	18·2%	16·2% Bank 12·9% Company	25·8%
Total of 1st 20 holdings	38·0%	41·0%	60·1%
Unconditional Voting Capital	£6,000,000	£6,187,500	£1,550,000
Total Issued Capital	£7,500,000	£6,712,500	£2,933,557
Debentures (Issued)..	None	None	£2,500,000
Reserves (1935) ..	£2,000,000	£200,000	£320,836
Directors among 1st 20 holders	1	3	0
Total number of Directors	13	11	6

For explanation of symbols see Table I.

Among the twenty analysed companies there were no clear cases of private ownership equivalent to the complete marriage of ownership and control assumed in the classical entrepreneur. Undoubtedly, however, there are such cases even among large British companies. For a subsidiary with all or the majority of its stock owned by a single parent company, the parent company is the classical type of entrepreneur, both owning and managing the subsidiary. It still remains a question, of course, whether there is any such entrepreneur for the parent company.

At the opposite extreme of an even distribution of holdings and probably complete divorce of ownership from control, there was one company (XII) among the twenty with no holding of over 0·5 per cent. of total voting power, and two companies each with only 2 holdings over 0·7 per cent. (1·3 and 1·1 per cent. in case XI, 1·7 and 0·8 per cent. in case XV). These *three* companies appear in Table II.

It is the middle state of partial divorce, however, that these twenty large companies illustrate most frequently. To qualify for partial rather than complete divorce of ownership from control,

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TABLE V.—*Percentage of Voting Power held by* 20 *Largest Shareholders in three Companies Showing Relatively* Concentrated *Ownership, much of it by* Other Companies, *or* Companies and Persons

Order.	Company XVII.	%	Company XIX.	%	Company VI.	%
1	Ca	11·3	Ma	11·4	Pa*	7·8
2	Cb	6·8	Ca‡‡†	4·1	Na	7·5
3	Cc‡	3·6	Cb*	3·8	Pb, Pc1, Pc2*	7·4
4	Pa	2·9	Cc	3·0	Ca*	5·9
5	Cd‡	2·3	Cd	2·8	Nb	1·8
6	Ba	1·5	Ce	2·1	Ma	1·7
7	Pb* + Pc	1·4	Pa	1·9	B	1·2
8	Bb	1·1	Ta	1·9	Nc	0·8
9	Ce	1·1	Pb + Pc	1·4	Pd	0·5
10	Ta	1·0	Cf***	1·4	Mb	0·4
11	Tb	0·9	Cg1	1·4	Nd	0·4
12	Cf*	0·9	Cg2*	1·4	Mc	0·4
13	Cg*	0·9	Ta, Pd, Pe	1·2	Ta	0·3
14	Na	0·8	Pf	1·0	Md	0·3
15	Ma	0·7	Mb	1·0	Pe*	0·3
16	Tc	0·7	Pg	0·9	Ne	0·3
17	Mb	0·7	Mc	0·9	Pc3	0·3
18	Pd	0·6	Tb	0·8	Pc4	0·3
19	Pe	0·6	Na	0·7	Cc	0·3
20	Mc	0·6	Tc	0·6	Pf	0·3

Summary:

Among 1st 20 Holdings: Percentage owned by other companies ..	26·9%	20·0%	6·2%
Total of 1st 20 holdings	41·5%	43·7%	37·2%
Unconditional Voting Capital	£4,435,792	£2,424,957	£6,718,248
Total Issued Capital	£5,335,792	£4,494,766	£8,683,069
Debentures Issued ..	Not stated	Not stated	£1,952,519
Reserves (1935) ..	Not stated	Not stated	£610,478
Directors among 1st 20 holders (if company, its Directors) ..	5	4	4
Total number of Directors	13	11	12

For explanation of symbols see Table I.

the largest twenty shareholders should own between them at least 20 per cent. of the voting power. This "twenty-twenty" rule ensures real control for the largest owners without fear of any strong opposition outside the group, since the percentage of voting power owned by smaller holders tapers off rapidly.* The twenty-first shareholder, in order of size of holding, owned not more than 0·6 per cent. in any of the twenty companies studied except one (Company XIV given in Table III), and after the twenty-first shareholder come thousands of relatively very small shareholders who would find it difficult to organize coherently.

The large owners may be either persons or companies or both. In *three* out of the twenty companies the largest twenty holdings in the hands of apparently connected persons (several of whom were directors) amounted to at least 23 per cent. of voting power; and there was no appear-

* See Prof. L. Penrose, *J.R.S.S.*, 1946, Pt.-I.

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TABLE VI.—*Percentage of Voting Power held by the* 20 *Largest Shareholders in Three Companies, Showing Various* Marginal *Types of Distribution among Various Types and Interrelationships of Owners**

Order.	Company II.	%	Company V.	%	Company XVI.	%
1	Pa + x	17·5	Na	12·4	Pa, Pb1, Pb2	1·9
2	Pb	9·2	Pa1	6·4	Pc, Pa, Pb3	1·9
3	Pc	5·7	Pa2*	4·6	Pa, Pb2, Pc	1·5
4	Ma	5·5	Ma	3·0	Na	1·5
5	Pd	5·4	Pb*	2·7	Pd1	1·5
6	Pe	5·3	Mb	1·7	Pi1,* Pi2, Pi3	1·4
7	Ta	4·5	Ia	0·8	Pb4	1·4
8	Pf	4·3	Ca	0·6	Pe, Pf1	1·3
9	Pg	4·0	Nb*	0·5	Pd2	1·1
10	Ph	3·5	Pa3*	0·5	Ta1	1·0
11	Pi	3·5	Pa4*	0·5	Pf2, Pf1, Pg	0·9
12	Pk	2·5	Pa5	0·5	Ph*	0·8
13	Na	1·8	Pa6	0·5	Pi1,* Pi2	1·0
14	Pl	1·7	Pa7*	0·5	Pi2	0·8
15	Pm	1·0	Pa8	0·5	Pi1*	0·6
16	Pn	1·0	Pa9	0·5	Pi4	0·6
17	Po	1·0	Pa10	0·5	Ta2	0·6
18	Pp + x	0·8	Pa11	0·5	Pk*	0·6
19	Pa + x	0·7	Mc	0·4	Ma	0·5
20	Pq + x	0·5	Pa2 + xx	0·4	Pl	0·4

Summary:

Connected Personal Shareholders ..		Pa's 15·9%	Pi's 4·4% Pb's 6·7%
Total in 1st 7 holdings	53·1%	33·3%	11·1%
Total in 1st 20 holdings	79·4%	38·0%	21·3%
Unconditional Voting Capital	£2,000,000	£2,000,000	£3,905,478
Total Issued Capital ..	£12,000,000	£8,750,000	£5,345,302
Debentures	None	£3,500,000	£1,205,428
Reserves (1935) ..	£1,690,620	£1,000,000	£200,000
Directors among 1st 20 holders	0	6	5
Total number of Directors	5	10	22

* II Concentrated ownership. Ostensibly unconnected persons.
V Concentrated ownership. Connected persons AND nominees.
XVI Marginal case of concentration of Ownership.

For explanation of symbols see Table I.

ance of any similarly coherent opposition group inside or outside these leading twenty holders able to summon anything like an equivalent vote. Company XIV in Table III is the clearest case of this concentration of power in a sort of oligarchy, but Companies III and XVIII also qualify.

Five of the companies analysed showed an apparently ruling oligarchy that was composed mainly of other companies. Three of these apparently company-ruled companies, VIII, X and XX, analysed in Table IV, were *virtually* subsidiaries with 20 per cent. or more of their votes in

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the hands of one (or two connected) parent companies. Two further companies presented a more interesting situation—shown in Table V. The gradient in the size of the first few largest holdings was in their case not so great. In Company XVII seven of the thirteen largest shareholders are companies, and own between them 26·9 per cent. of the voting power. In the other company of similar type (XIX) eight companies appeared among the twelve largest shareholders and owned 20·0 per cent. of the voting power. Here it is probably a case, not of a holding company controlling policy, but rather of a series of participating companies each desiring a finger in the pie of policy. This view is supported by the fact that some of the directors of the participating companies are directors of the analysed company. As noted in Table V, four of the companies among the largest thirteen shareholders in Company XVII have one of their directors (including chairman) on the Board of the Company. In the other company of similar type (XIX), five of the companies among the largest twelve shareholders have one to three of their directors (including chairman) on the Board. In America all beneficiary holders of 10 per cent. of any corporation stock are now forced to report to the Securities and Exchange Commission. It is significant to note Gordon's* conclusions as to 155 of the largest non-financial corporations that, apart from directors and officers, those large holders, especially among the railroads and utilities, are chiefly other corporations.

Control may, of course, be exercised by both persons and companies. Of this, there appears *one* example among the companies analysed: a coal company (VI in Table V) with three holdings amounting to 21·2 per cent. of voting power. One of these holdings is owned by an engineering company, another by a director of that company, while the third is owned jointly by three persons, one of whom is also a director of that company. Clearly, the engineering company, though it does not constitute a holding company, may be said to participate strongly in the control of the coal company—to have at least two fingers in its pie.

Five companies out of the twenty analysed cannot be assigned. Two (VII and XIII) had too much of their stock held by nominee companies to give any evidence of the real seat of control, and three others (I, IV and IX) had a distribution of shares that made assignment doubtful. Here holdings are *fairly* unevenly distributed; 10 per cent. to 20 per cent. of voting power is owned by the largest twenty shareholders. Such a distribution admits the *possibility* of a small controlling group of shareholders, and makes a complete divorce of ownership from control uncertain; and yet there is not enough cumulative evidence (such as 20 per cent. of voting power, "coherence" and directors among the twenty largest holders) to make even some partial ownership control *probable*.

The remaining three companies whose largest shareholdings are given in Table VI are assignable; but only as marginal cases. In Company XVI the largest twenty shareholdings add up to 21·3 per cent. of voting power, but it is not on the face of things possible to connect up these "leading" shareholders, except as a group of Pb's (connected with Pa's and Pc's) owning 6·7 per cent. of the votes, and of Pe's (including a director) owning 4·4 per cent. Company II shows extreme concentration of ownership, but no connections or directors among the largest shareholders; while Company V shows fairly high concentration of holdings, but the largest holding is that of a nominee company. Companies II, V and XVI may be assigned as marginal cases to Partial Divorce of Control from Ownership.

This "leading share" analysis is of course only one step in the search for the entrepreneur. It must be supplemented by *ad hoc* information on the particular circumstances and personalities of each of the large companies under enquiry. Economists have found benefit from direct contact with business men, but have perhaps unduly neglected the recorded information ready to hand. My own experience is that business men's replies to questionnaires or interviews are difficult to obtain in sufficient volume, are not always accurate or relevant, and consume a great deal of the time of investigators who must be highly skilled and *persona grata*. Such a direct *ad hoc* attack on the subject should not be undertaken until the accessible records and published material is exhausted. This published material, thanks to official censuses, is increasing in volume, and can be summarized along the required lines by relatively cheap clerical labour. And when making *ad hoc* enquiries, it is useful to have the public records as a stepping-off point for questions. Idle questions can be avoided, and pointed questions put. The general question "Who runs such and

* R. A. Gordon, *Quarterly Journal of Economics*, May, 1938.

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such a company?" is not so easy to get accurately answered as "Who is this particular large shareholder who is behind the X Company?"

The analysis of a mere score of companies, however large, though useful as a pilot enquiry to indicate the snags, the types of control likely to be encountered, cannot of course give the relative frequency of the various types. But the brief reviews of results together with Parkinson's* evidence, may justify the following tentative conclusions:

(1) That the Somerset House records may clarify the control situation of at least half the large joint stock companies, at any rate as a preliminary step. For instance, a clear distinction can usefully be made between companies where the largest twenty shareholders own (*a*) over 20 per cent., (*b*) less than 10 per cent. of the votes. The chief obstacle to clarification of the other companies is the nominee company or personal dummy permitted by existing company law.

(2) That the *partial* divorce of ownership from control seems characteristic of large companies, rather than the entrepreneur owner-manager type, or the complete divorce of control from ownership. Out of the twenty large companies investigated, twelve showed 20 per cent. to 65 per cent. of the votes owned by the largest twenty shareholders; only three companies less than 10 per cent.

(3) That the control of one company by others, not amounting to the complete holding of all or a majority of the shares of one company by another, but rather to participation in its affairs, is probably a frequent case hitherto perhaps somewhat neglected by economists. This arrangement might be a useful device for co-ordinating companies whose technical activities were interdependent—or a device for any one participating company exercising a veto on the others.

4. *Voting Rights, Directors' Qualifying Shares and Pluralist Directors*

The analysis of the recorded distribution of holdings in companies, though more economical as a first step than direct questioning of business men, yet requires a considerable expenditure of funds for clerical labour. In America and England, only a few of the largest of companies have up to the present had the distribution of their shareholdings published. Until research institutes finance this line of enquiry, the analysis of company control on a wide scale must get along with signs, small perhaps, but already published and easily summarized.

In England the official *Stock Exchange Year Book* makes public two indices reflecting the type of control of individual companies. It gives for most companies the qualifying shares that a director must hold and the voting rights of different classes of shares, if there are such different classes. To measure possible varieties and types of control (as well as policy) among typical British public joint stock companies of all sizes a sample enquiry was conducted at Birmingham University under my supervision. Every tenth public company in alphabetical order was picked in three sections of the *Stock Exchange Year Book* for 1936. Mr. J. Siviter was responsible for the Commercial and Industrial Section; Dr. W. Baldamus for the Iron, Coal and Steel, and the Breweries and Distilleries sections. These three sections embrace all "trading" companies as against companies in financial, transport, or mining sections. In this sample of companies a distinct variety was found, both in qualifying shares and voting rights.

The qualifying shares were given in the *Year Book* for 315 companies out of the 436 in the random sample—i.e. 67 per cent. For all sizes of company but the smallest, however, they were given for 80 per cent. of the companies. Taking the qualifying shares for the Board as a whole, Table VII presents the number and distribution of companies with specified percentage of qualifying to total shares. Clearly, directors generally are not legally required to be shareholders to any great extent. This sign of the divorce of control from ownership is particularly marked in the larger companies; 65 per cent. of the companies with over £500,000 of capital, require less than 0·4 per cent. of the shares to be owned by the whole Board.†

That larger companies are controlled by men with a smaller proportionate stake in the stock, in fact, and not just as a legal minimum, was brought out in detail by Mr. R. A. Gordon for

* *Scientific Investments*, Chapter I.

† In his *Scientific Investment* (p. 141), Parkinson gives particulars for fifteen large British companies. Only two require the Board to own more than 0·4 per cent. of shares. In their *Financial Democracy* (p. 85) Miller and Campbell give particulars for twenty large companies, four of them duplicating Parkinson. Of the additional sixteen companies, only two require the Board to own more than 0·4 per cent. of shares, and none that they should own 0·5 per cent. or more.

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TABLE VII.—*Board of Directors' Qualifying Shares in a Sample of English Trading Companies*

Per cent. of all Shares to be held as Qualifying Shares by the Board.	All Sample Companies.		Companies with over £500,000 Capital.	
	Number.	Percentage.	Number.	Percentage.
5 per cent. and over	9	3	0	0
1 per cent. up to 5 per cent. ..	111	35	7	8
0·4 per cent. and up to 1 per cent.	88	28	23	27
0·2 per cent. and up to 0·4 per cent.	46	15	20	24
Under 0·2 per cent.	61	19	34	41
	315	100	84	100

American corporations.* In corporations with assets between $5 to $100 million, the non-officer directors held about 4 per cent. of the voting common stock on the average, using the median percentage as the average. In larger corporations than this, the proportion sinks below 2 per cent. If *all* administrators are taken (including directors and executive officers), the median proportion of voting common stock they hold falls steadily from 21·45 per cent. in the $5–10 million to 5·83 per cent. in the $100–250 million companies.

Dealing with 155 of the largest of American industrial, utility and railroad corporations—all the giants analysed by Berle and Means for which the needed information was to hand—Gordon found the divorce of ownership from control further accentuated. The median proportion of voting stock owned by all administrators for these 500 million dollar or more corporations was 1·74 per cent. But there was wide variety in degree of "divorce." In 40 per cent. of these giant companies all the administrators between them owned less than 1 per cent. of voting stock; in 12 per cent. of companies they owned 1 to 2 per cent.; in 18 per cent. of companies 2 to 4 per cent. At the other extreme there were six companies (4·0 per cent.) where administrators owned 20 to 25 per cent., five in which they owned 25 to 50 per cent., and two in which they owned over 50 per cent. of voting stock. Here they were, in fact, no longer administrators, but quasi-entrepreneurs.

The voting rights of shares tend to be more unequal in the larger than the smaller English companies. A line may conveniently be drawn between companies who have one denomination of shares only, or allow equal rights (i.e. one vote per given value of share) to all denominations; and companies, on the other hand, who granted unequal voting rights as between denominations —e.g. that preference shares may not vote unless their dividend is in arrear. Greater inequality of rights in larger companies was evident in all sections of the random sample of English companies, but full details were only obtained for the Iron and Steel and Coal, and the Brewery and Distilling sections. Dividing companies into two sizes, small where capital was £200,000 or less, large where it was more than £200,000, unequal rights were set up by seven large brewing companies out of nineteen, but only by two small brewing companies out of fourteen. Eleven large iron, steel and coal companies out of nineteen set up unequal rights, while all four of the small coal, iron and steel companies allowed equal rights.

Among the eighty largest English trading companies Mr. H. M. Davis traced the ratio of capital with full voting rights to total capital. The ratio was 100 per cent. (i.e. equal rights) for only twenty-eight of the companies. For thirty-one companies, voting capital formed 61 to 99 per cent. of total capital, for eighteen the ratio was 21 to 60 per cent., and for three it was 20 per cent. or less. Clearly the larger companies show a wide variety but, on the average, their votes are more unequally shared, conducing to at least *partial* divorce of control from ownership.

Pluralism in directorship can probably be taken as a sign of divorce of control from ownership. A man who holds several directorships in companies can obviously not own the capital of all of them, or even the minimum to give some control, unless they are very small or he is fabulously rich. Moreover, in a company privately owned the owner-manager is likely to be chary of admitting persons on the Board who have outside interests. With the exception of one or two professional specialists, the Board is more likely to consist of full-time managers who have little leisure, opportunity or reason for directing other companies, unless they be subsidiary or associated

* *Quarterly Journal of Economics*, August, 1936 and May, 1938.

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companies. And what is true of privately owned and controlled companies appears partly true of family controlled companies or companies formed out of family businesses—the directors keep themselves to themselves and out of other companies, while the family circle is in turn largely closed to the multiple director.

Statistics of plural directorship can easily be obtained from the *Directory of Directors*. But here we are concerned with its extent in a sample of companies, and, within the sample, differences in its extent according to the size of the company. From the random sample of all trading companies in the *Stock Exchange Year Book* made by Siviter and Baldamus, it appears from Table VIII that the directors of large companies hold more directorships on the average than directors of small companies. Half the directors of the smaller companies were pluralists; 12 per cent. held six or more directorships, and 4 per cent. over ten. But three-quarters of the directors of the *larger* companies were pluralists, with 30 per cent. holding six or more directorships and 13 per cent. over ten. This situation seems at first sight contrary to logic, since it might be expected that the direction of larger companies would involve greater responsibility, time and energy, and thus be less frequently multiplied, than the direction of smaller companies.

TABLE VIII.—*Number of Directors of Sample Companies of Various Size holding Specified Number of Directorships*

Directorships held.	Capital less than £100,000.	%	Capital £100,000–£500,000.	%	Capital over £500,000.	%	All sizes.	%
One	318	50	436	48	156	25	910	42
Two or Three ..	168	27	226	25	163	26	547	26
Four or Five ..	68	11	120	13	118	19	306	14
Six to Ten	53	8	100	11	105	17	258	12
Over Ten	27	4	28	3	81	13	136	6
All Directors ..	634	100	910	100	623	100	2,157	100

Part of the explanation of this paradox fits in with our assumption that plural directorships are a sign of divorce of control from ownership. The control of larger companies is more divorced from ownership and their directors are not tied down to directing only where they own substantial capital, but can pay attention, promiscuously, to one company after another.

Here again there are snags to encounter before the statistics can lead to true diagnosis. Many pluralist directors are so because they are on the Boards of a holding company, and perhaps of several of its subsidiary companies. In that case, since the holding company controls its subsidiaries by virtue of ownership, multiple directorship is not necessarily an additional indication of divorce of control from ownership. The solution is to exclude directorships in subsidiaries as far as these are known. To some extent the figures given above achieve this exclusion, since they refer to the directorships of the "principal companies whose shares are dealt with on the Stock Exchange," but, even among these, as we know, there may be virtual subsidiaries which only an analysis of holdings can disclose.

The published and easily accessible facts about equality of voting rights and multiple directorships will probably be found to have some relation to the less accessible facts about the distribution of individual holdings. From the slender evidence of the twenty companies whose stock was analysed, it looks as though directors holding any of the twenty largest holdings in these companies are not, on the whole multiple directors. Furthermore, great inequality of voting rights (where voting shares were 26 per cent. or less of total shares) was found in four out of the twenty companies. This inequality did not occur where the distribution of holdings conferring voting rights was relatively even among the shareholders. This seems consistent. If the purpose of unequal voting rights is to concentrate power, it would clearly be foolish to diffuse power widely among individuals in the favoured voting class of share. These are only working hypotheses, however, to be checked by further analysis of the holdings of companies.

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5. *The Antecedents and Occupations of the Director*

When administration is entirely or largely divorced from ownership, the variety of policy adopted is likely to depend on the type of administrator in control. Even if maximum profit be a real objective there may well be differences of opinion how by various investment policies to distribute the profit over the short and the long term; or whether an expansionist high turnover cum low margin of profit policy will aggregate more profit than a low turnover cum high margin policy. Within the range of indeterminateness the policy of the key man is likely to depend, in the psychologist's phrase, on his attributes and conditioning.

In my Logic of Industrial Organization* I put forward tentatively certain typical "key" men that might control a firm, and was so bold as to assign each type marks for his efficiency in certain lines of policy. Some of these policies referred to questions internal to the firm such as co-ordination and appointment of staff. But three of them involved direct or indirect economic relations with the outside world, namely reinvestment of capital, initiative in large-scale expansion, and degree of co-operation or combination with other firms.

The "key" men in control in the Joint Stock Company might be General Managers, Managing Directors, or (as noted below†) extraneous Directors brought from outside the firms' employment, but whatever their official title, their policy would be conditioned by their antecedents, status or main occupation. The varieties of possible key men which I distinguished as likely to effect different varieties of policy were:

I. The Self-Made Entrepreneur.
II. The Family Head.
III. †The Financier.
IV. †The Guinea-pig Director Type.
The Interlocking Director.
The Professional Man Director.
V. The Ex-Employee.
VI. The Ex-Technician.
VII. The Trained Administrator.

There is no need to repeat my argument,‡ but it is common sense, for example, that if a key man is an engineer or technician by training, he may itch to put profits back into engines or the improvement of the technical quality of the product. If a key Director's training is commercial or professional, such as that of a solicitor or accountant, or if the key man has just worked his way up the office and has since childhood been an employee of the company, then he is likely to be more cautious and to keep profits in liquid form. Merchants are accustomed to the self-liquidating form of asset and may well be shy of fixed commitments.

It remains to find statistical or other objective means of detecting the type of key man in control. A start was made with the 463 companies selected at random from the *Stock Exchange Year Book* by noting the past, or other present, occupations of their directors. Findings as to the interlocking Directors have already been summarized. From the record it can also be stated that the appointment of certain professional men to directorships is considerable. On the Boards of the 436 sample English trading companies we traced at least 127 accountants, 58 lawyers, and 88 men with some admitted technical qualifications.§ The number of the accountants and technicians among the directors, though not the lawyers, increased with the size of the company. For companies with capital below £100,000, technical men numbered 2·6 per cent., accountants 3·2 per cent. of all directors, roughly 11 and 14 per hundred companies.§ For companies with capital between £100,000 and £500,000, technical men number 4·7 per cent., accountants 5·0 per cent., of all directors, roughly 23 and 25 per hundred companies. While for large companies with capital above £500,000 technical men were 4·2 per cent., accountants 7·6 per cent. of all directors, roughly 29 and 53 per hundred companies.

* Chapter VII: *The Stimulus to Enterprise*.
† Usually part-time, extraneous Director.
‡ *Logic of Industrial Organization*, 1933, pp. 204–220.
§ Since experts on the Board of a company are likely to pull more weight than non-expert Directors, their number per hundred companies is more significant than their proportion to total of Directors.

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The high proportion of large companies where accountants sit on the Boards is particularly significant for policy. Accountants tend by nature to urge "sound" finance (i.e. liquidity in balance sheets), and when costing, normally insist on depreciation and other overhead costs remaining constant at a standard percentage of prime costs whatever the volume of business, and even though additional business may add no cost except for materials and direct labour. This may often explain the survival of the small entrepreneur during depressions. Free from mathematical averaging, he often hits on the marginal principle by common sense. Accountants, when in control, seem, in short, to adopt policies tending toward contraction of business during depression.

In spite of the appointment of technically trained and professional men (and even some trained specifically for administration) to the higher administrative posts of large-scale firms, many who hold key positions are self-made men who started in business as entrepreneurs in trade or finance and expanded in power with the expansion of their own business. Other key men in control of policy classed as "family-head type" have inherited the position, and the policy they pursue may differ radically from that of the self-made entrepreneur.*

The relative frequency of these types of key men can be ascertained up to a point by reference to *Who's Who*, the *Directory of Directors*, and other publicly available sources. Such ascertainment would be a valuable first line of research.

Control by financiers may also be expected to have a characteristic effect on policy, and often leads to much-documented† abuses. Though difficult, it is important to know a financier from the evidence of the records. Financiers are by definition suppliers of finance *generally*. Unlike the Directors of a company of family type with control only partly divorced from ownership, financiers do not confine their activities to one particular company, and are likely to be found among the plural directors already described. Quite apart from the interlocking of directorships between associated companies there are, of course, other reasons for a man holding several directorships besides having financial interests. He may possess a reputation for ability as a "general utility" or general experience director; he may be a specialist supplying the services needed by business generally (for instance, an expert lawyer or accountant); he may bring in custom or supplies necessary for production. Finance is only one factor on the supply side, nevertheless clues to the *financier* pluralist can perhaps be found (1) in the number and variety of industries which he directs—which will distinguish him from the specialist pluralist; (2) in his holdings of shares in key holding and participating companies where power is highly geared in relation to the value of holdings—which should distinguish him from the general experience director. This information on the ramifications of individuals' shareholdings and directorships gives a clue not only to track down the financier, but to help discover his particular policy, since his major interests may thereby be disclosed. Two main obstacles to the detective remain, however—the nominee dummy and the nominee company under which the beneficiary owners may, by law, mask his identity in the records.

In the random sample of 436 companies, one further objective test was used to detect a type of key man. The type was the guinea-pig and the test a title. Gentlemen (or noblemen) whose qualification for a seat on the board of directors is largely the name they bear are vulgarly called "guinea-pigs."‡ In so far as their vote or votes are effective in initiating or checking policy, the effect is likely to be in opposition to any great re-investment of gross profit.§ The titled guinea-pig is brought in to attract shareholders, and as a representative of shareholders' interests he is likely to want the highest possible dividends declared. The random sample of English companies disclosed 172 directors with a title, forming over 8 per cent. of all directors. Titled directors were particularly frequent in the largest companies; among the sample companies with over £500,000 capital they numbered almost 15 per cent. of all directors; indeed, 48 per cent. of all these large companies had some titled director on its Board, and in the Iron, Coal and Steel section all the sample companies of this size had this distinction. At a rough estimate, almost half the titled directors inherited their title or acquired it by prowess in the fighting services or sport and not in business and can be considered as probable guinea-pigs. Titles are an easy mark for a pilot

* *Loc. cit.*
† E.g. Löwenthal, *The Investor Pays*. W. Z. Ripley, *Main Street and Wall Street*.
‡ R. Ashworth, *Limited Liability Companies*, 1925, p. 124.
§ P. S. Florence, *Logic of Industrial Organization*, 1933, p. 213.

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enquiry,* but the schooling (e.g. at Public Schools, University Commerce courses, etc.) likely to condition outlook, or the training in administration (if any) of possible key men† could be included in a more thorough investigation.

6. *Summary and Conclusions*

1. The individual policy of large-scale firms is admitted to be often a determinant factor in the economy of modern industry. Industry to-day is not planless so much as a congeries of plans about the price, quality, or design of their products or the amount produced, worked out by separate individual firms. Where such plans can, like financial policy, be statistically measured, they show wide variety even under seemingly similar circumstances.

This suggests that there may be a corresponding wide variety in the seat of control of the firms, and that different sorts of controllers make some difference to policy. For instance, under the control of the classical owner-manager entrepreneur, investment was and probably is largely made out of reserves from profit; this does not appear true where managers and owners are different persons. In short, economic policy is under modern conditions not just a reflex action following mechanically from economic forces. If changes in economic life to-day are to be understood, it is necessary to trace the policy of firms to their personal source.

2. At the present stage of research an article must limit itself to exploring the means for finding those who are in control of policy in the modern business. Certain accessible documents and records exist in England such as the *Register of Joint Stock Companies*, the *Stock Exchange Year Book* and the *Directory of Directors*, and these should be drained of their useful information before tackling business men direct. How far this documentary evidence is useful and not merely façade is discussed at some length, particularly the camouflage of the nominee dummy or nominee company that is permitted by English company law to be registered in the place of the true beneficiary. Citation of actual cases show, however, that a good deal of true evidence can be secured, sufficient to assign at least half the large joint stock companies to specific types of control. It may be necessary to piece together fragmentary records from different sources, somewhat in the manner of a medieval historian, yet in view of the influence exerted by comparatively few large companies, and still fewer "communities of interest,"‡ detailed case-histories of their working structure, functioning and behaviour will amply repay the effort.

3. The joint stock company or corporation is to-day the leading form of industrial organization in all commercially developed capitalist countries. Evidence recently published in the United States and Canada shows what a wide variation in the real seat of control is masked by a uniform joint stock company constitution. In the attempt to find the true controller within the framework of the joint stock company, two studies have been undertaken at the University of Birmingham: (1) An analysis of the distribution of the larger holdings in twenty of the eighty largest trading companies together with details of their directors' other directorships. (2) Details of the voting rights of various shares, minimum directors' qualifying shares, occupation, and the other directorships of directors, in a one-in-ten sample of all sizes of British trading companies, taken from the *Stock Exchange Year Book*.

4. This English evidence goes to show that though in a few companies control may still lie with ownership as it did in the classical situation of the personal entrepreneur, there is usually a more or less complete divorce of management from control. Unlike the American evidence, less complete divorce appears to be more frequent than the complete divorce that is equivalent to administrative control. The companies whose holdings were analysed were too few to justify any estimate of the frequency distribution, but were enough to show the limitations of arguing "classically" only from an assumed owner-manager entrepreneur paid by profit. It is necessary to follow the relation to policy of two further main types of control—incomplete divorce of control from ownership, and the complete divorce.

5. The essence of *incomplete* divorce of control from ownership is that ownership is so distributed that a small coherent group of shareholders can have control though they own only a minority of the capital. Once the real coherence and control of this group is established (and methods are indicated for doing so) a "partial" classical entrepreneur has been found, since

* See Miller and Campbell, *Financial Democracy*. ‡ Samuel, *Shareholder's Money*.
† Discussed in Theory in Chapter VIII of my *Logic of Industrial Organization*.

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control is exercised by virtue of partial ownership. Discovery of different forms of control is barren unless they make some difference to policy, and it remains to discover what the motives and objectives of this composite partial entrepreneur may be. Sometimes the entrepreneur is obviously a family with family interests; sometimes the entrepreneur is a group of financiers whose identity and policy can be inferred from the ramifications of their other interests. The "entrepreneur" was in some companies found to be composed of other companies. If one company holds a large proportion, not necessarily half of the voting power, but say 20 per cent., it can be taken as virtually a holding company, determining policy like any single personal entrepreneur. Often, however, several companies own each just a modicum proportion of voting power, say 1 to 12 per cent., and may be taken as merely "participating" in the control. Here the technical relation of the business activities of the several participating companies may give a clue to policy, since these activities are often co-ordinated through the company in which they participate.

6. The essence of complete divorce of control from ownership is that ownership is relatively equally distributed among shareholders, so that no individual or coherent group holds enough of the voting capital to exercise control through that means. Control stays, therefore, with directors and managers who are virtually administering other people's property and are remunerated, not by profits from ownership, but by salary and fees. Assuming economic motives, this may discourage enterprise entailing risk and lead to rather humdrum maintenance of conditions.

But the economist's assumptions should perhaps be discarded. Perhaps administrators are not merely economic men, and it is important to discover the personality, antecedents, occupation and conditioning of large-scale administrators. Financial policy may be influenced, for instance, towards a "sound" liquid position and away from enterprising investment by the custom of appointing professional men, particularly accountants, to directorships—a practice which appears to be fairly frequent.

7. Though the most prevalent to-day, the joint stock company is not the only form of constitution for a large scale undertaking. Alternatives that have proved practical in certain industries are consumers' co-operation and State operation, local or national. Control in both these forms is fundamentally administrative in character, since the directors and officials are not handling their own property. Co-operative societies publish detailed records with far less camouflage than joint stock companies, and it is possible to show that the financial policy of the large-scale, manufacturing co-operative wholesale societies is one of extreme "soundness" and liquidity, compared to that of the bulk of joint stock companies. Control of these societies lies in the hands of directors and officials paid by salary, possessing in fact secure tenure, and trained mainly as retail society managers or directors having to render a public account of their stewardship. The same policy of "soundness" as against investment may be true of the controlling administrators of State undertakings, paid as they are by salary and seldom dismissed, if they are "conditioned" to the same fear of public criticism on details.

8. The ultimate practical problem raised is thus how to avoid a condition that answers to most of the tests of bureaucracy; how to recruit administrators who will be as enterprising in investing capital as the entrepreneur is often assumed to be, and probably once was. This administrative enterprise involves risking, but risking wisely, other people's money in the effort to provide more and better and new kinds of goods and services. It is a quality probably fairly scarce among the population. Can enterprise be inculcated by education? Can enterprise be detected by psychological tests and promoted accordingly? Can it be stimulated by special forms of rewards not so expensive to the community as profits? These are the sort of questions that an administrative science should be asking, and answering with the help not only of economics, but of psychology and political science, all supported by statistical enquiry.

APPENDIX

List of Joint Stock Companies

I. Guest, Keen & Nettlefolds, Ltd.
II. Union Cold Storage Co., Ltd.
III. J. Lyons & Co., Ltd.
IV. City of London Real Property Co., Ltd.

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V. Allied Newspapers, Ltd.
VI. Amalgamated Anthracite Collieries, Ltd.
VII. British Celanese, Ltd.
VIII. Furness, Withy & Co., Ltd.
IX. General Electric Co., Ltd.
X. British Match Corporation, Ltd.
XI. Bleachers' Association, Ltd.
XII. Harrods, Ltd.
XIII. Associated Portland Cement Manufacturers, Ltd.
XIV. Tate & Lyle, Ltd.
XV. United Dairies, Ltd.
XVI. Wall Paper Manufacturers, Ltd.
XVII. Amalgamated Metal Corporation, Ltd.
XVIII. Mitchells & Butlers, Ltd.
XIX. Imperial Smelting Corporation, Ltd.
XX. Associated British Picture Corporation, Ltd.

Discussion on Professor Sargant Florence's Paper

Sir Henry Clay : It gave me great pleasure to accept the invitation to propose the vote of thanks to Professor Sargant Florence. I expected him to produce an interesting and stimulating, not to say provocative paper, but I welcomed an opportunity of thanking him also because this paper is only the latest in a series of books and papers in which he has performed a great service to economic studies over a generation—the service of insisting on the statistical approach to economic problems, and illustrating how that approach was possible. Marshall, in a letter to Bowley, said once that nothing would do more to promote the understanding of economic questions than two things: first to set down what statistics has to say, and secondly to set down the questions to which statistics will not give the answers. This paper, in spite of my general appreciation of Sargant Florence's work, seems to me to illustrate rather the second of Marshall's requisites; it puts down a lot of questions to which statistics will not give the answer.

What the paper seems to offer is not so much a statistical as a historical approach; Professor Florence has used the Company Registers in Somerset House, the great source of historical material, to answer his questions. It is difficult to measure factors if one quarter of the sample taken happens to conceal the particular matters one wishes to measure. It is difficult again to measure if a satisfactory definition of control cannot be framed; control must be defined specifically if it is desired to measure it. Berle and Means used one definition; the tendency of this paper is to identify control with the actual ability to determine policy, which usually rests with the board of directors rather than with the salaried management.

The chief point I wish to make is that there are difficulties in relating the seat of control to the ownership of stock by any sort of ratio or proportion. I do not suppose Professor Florence, when he spoke of the 20–20 rule, really meant that he had discovered any rule that 20 persons tended to hold 20 per cent. of the stock of the company; it was merely a rough test he took to the data. But I doubt whether any close relationship can be traced between ownership of stock and control, except when 51 per cent. of stock enables one person to exercise legal control.

The difficulty arises from the fact that the joint stock company is not in the last resort an economic entity or device. It is a legal device, a legal entity, and, although one of its chief purposes was to make possible the separation of control in the sense of management from ownership, it serves a great many other purposes, and these other purposes may affect both the distribution of the ownership and of the control. The diversity of conditions which are met even in a small sample like the one we have had put before us this evening is so great that it is difficult to establish any uniform or general relation. The circumstances which constitute the environment of different companies vary so greatly. Professor Florence commented on the fact that he could not find in this country, although he found it in America, a case of the classical entrepreneur assuming the form of a corporation and owning the bulk of the stock. The explanation is surely that our taxation system is different from that of America. If the records of offers for sale and new issues in the 'thirties are studied, there is no difficulty in finding cases in which companies which had

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conformed to the classical entrepreneur type had, owing to a change in the income tax law, which made the owner personally liable not only for income tax on the whole of the earnings of his company, but for surtax as well, been transformed themselves into true public companies with a wide distribution of stock-holding. So long as the former proprietor retained a majority of the total stock he was liable to be stopped from doing what most self-respecting entrepreneurs do, that is, putting away to reserve as much as possible and avoiding surtax on it. I do not think we shall find any case in this country of a single shareholder owning 40 per cent. of the company, at any rate if it might render him liable to surtax.

Again it has to be recognized that many large holders of stock in companies do not want control. Investment trusts do not as a rule, insurance companies do not, and they are two of the largest corporate investors. Banks are occasionally left with a large holding of the stock of a company to which the bank has made advances; they too are most reluctant to exercise any sort of control. Mere age has an important influence on the distribution of ownership. If Tate and Lyle had been a company as long as the Bleachers' Association, fewer Tates and Lyles would probably be found among the stockholders and there would be a much wider distribution of stock. We are forced to turn back to the circumstances of origin if we are to understand either the distribution of ownership or the distribution of control. Most industrial concerns originated in an individual or family business; at some stage these businesses are turned into companies for convenience of administration. An obvious example is the 19th century industrialist approaching the age when he cannot manage his business and has only daughters to succeed him, who creates a trust to look after the daughters' interest without any change in the control at all. Where a company has been originally formed or subsequently transferred by public issue, the fact of public subscription tends to produce a much more widely diffused holding of capital. There are, however, not many cases of industrial companies formed initially by public subscription; the market waits until the concern is formed and it is convenient to the founders to sell it to the public.

Another case, illustrated particularly by the Amalgamated Metals Corporation, is the tendency for all sorts of co-ordinating and interlocking arrangements to arise as a result of the convenience which the joint stock form offers. It may be desirable to extend a concern's interest forward to its customers, or backwards to its suppliers or, it may be, to make arrangements with competitors which may account for the high proportion of concealed holdings. Two types of company which are well known and illustrate the possibilities of this are South African mining groups and Indian Agency Companies. Practically the whole of the gold mining of the Rand is controlled by half a dozen companies. In such cases the actual stock-holding of the controlling or managing company may be much less than 20 per cent.

Finally there is the tendency, which I think is most interesting, towards what I would call functional corporate organization. It is a great convenience very often to segregate a new function or an existing function in the hands of a separate company. That is done mostly by the setting up of a subsidiary company; manufacturing firms set up subsidiary sales companies at home or in overseas markets, and will often give them effective independence. If that tendency develops it would be most interesting, because it might result in a legal garment being provided for industry which fitted it without constraint. At present the relation between the economic distribution of functions and interests and legal forms is rather rough; in most cases there is no exact fit. Joint stock companies have become too complicated for ready inference of the true relations between distribution of control and distribution of stock ownership.

I have much pleasure in moving a hearty vote of thanks.

Mr. G. L. SCHWARTZ: I have pleasure in seconding this vote of thanks and in paying special tribute to Professor Florence for his choice of subject. Indeed, I am going to take up most of my time in paying a tribute on that aspect. The neglect of the study of the joint stock company is one of the most striking features of modern English economics, and by "modern" I mean from Marshall onwards. It is part of the general neglect of the study of the constitutional and legal framework inside which the market works that is an outstanding deficiency of English economics.

When Professor Florence says that the public joint stock company has kept economists guessing as to the real seat of control, the appropriate comment is that as far as English economists are concerned they have not troubled to guess. Pertinent things were said about the joint stock

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company by Adam Smith, who emphasized the tendency to unenterprising administration which Professor Florence characterizes as a possible danger to-day. He was also quite pungent in his view that the only scope for these companies was in activities that lent themselves largely to routine, such as banks, insurance, canals and waterworks. When John Stuart Mill looked for an analogy with the neglect, indolence, spiritless service, and lack of sense of responsibility that were likely to characterize the conduct of the directors of a company, he could find it in only one other line of activity, or inactivity, namely, that of politicians. This tradition of disdain was maintained by English economists right up to the middle of the 19th century with McCulloch fervently echoing Adam Smith. It persisted longer than that, but the subject became a dead letter so far as economists and sociologists were concerned after the general grant of freedom of incorporation in the fifties. Yet as we all know, the company has become the predominant form of business organization. Sir Henry Clay emphasized that it was less of an economic device than a legal entity, but that does not dispose of the fact that the joint stock company to-day is an astounding economic reality. But this development by which the joint stock company has become the dominant form of business enterprise passed almost without comment by British economists and sociologists, and as far as they are concerned, a few men with a finance company of £100 capital could have secured control over the whole of British industry without contemporary economists remarking upon the fact. It is significant that no economists are ever asked to sit upon a commission enquiring into company law reform; nowadays they are not even asked to give evidence. I wonder how many papers on company law and organization have been given before the Society, or how many informative articles have appeared in the *Economic Journal.*

It is fortunate that the United States for various reasons has been forced to devote considerable attention to the rôle and operations of corporations, otherwise there would be very little literature on the subject available in English. The great authoritative work on companies in this country is by Professor Scott, and that carries the subject up to 1720. In saying all this I am not overlooking the work of Professor Florence; indeed I am paying him a hidden compliment.

He happened to refer to the guinea-pig director in one part of his paper. It is significant again of the intellectual divorce of company matters from general economic and social considerations that when, during the hearings of the Company Law Amendment Committee of 1925–26, witnesses objected to guinea-pig directors on sociological grounds, the Chairman ruled that commercial organization and not sociology was under discussion. I do not know whether Professor Florence would submit to that sort of snub to-day.

I have only left myself time to speak on one other aspect of the paper. Can anything be done about concentration of control or the divorce of control from ownership, and ought anything to be done about it? On the first question, can anything be done, a great deal could be done by simple changes in company legislation. There I would agree with Sir Henry Clay in emphasizing the legal aspect of the company. Why, for example, should a company be allowed to hold shares in another company? It is a powerful device for concentration, but it has just been allowed to happen; it has never been argued out, it was allowed to go by default. There may be good reasons for it, but they have never been discussed publicly or even privately so far as I know. Why are there no statutory provisions relating to voting rights; why permit one £1 share to carry one vote and another £1 share to carry 50 votes? Again, there may be good reasons that have never been thought out. It is like the general attitude towards monopoly developments in modern economy. Most people assume that they are inevitable, and very few people examine the possibilities of changes in the legal framework which might drastically curb monopoly power simply because existing legislation either consciously or deliberately fosters it.

That brings me to the question, ought anything to be done about it? We should recognize that under the aegis of the joint stock company—the corporation, as it is called in the United States—has been built up the most formidable productive machine that the world has ever seen, and we must recognize that, as in other lines of activity, the driving force has come from the small minority inside the organization. The Royal Statistical Society has had a very successful career for over a century, and I surmise that all along it has been run by not more than half-a-dozen active persons, while the rest of us are content to go along as functionless shareholders. The company form of organization worked well for a long time, but it coincided for the greater part with an age of expansion, and it can be argued that it brought about that age of expansion very successfully up to 1914. That accounts for the lack of interest on the part of economists and other people in

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the constitution of the joint stock company. It is significant that Professor Florence's chief apprehension is that the developments he has described may be inimical to enterprise, and he implies that these developments are a halfway house to bureaucratic administrative control. That criticism of his in effect brings us back to the line of criticism taken by Adam Smith, namely, that the joint stock company made for lack of enterprise.

On that I have only one final comment. One can talk of guinea-pigs in private industry, but there are already signs that the new public boards in the nationalized industries may become homes for aged horses.

The vote of thanks was then put to the meeting and carried unanimously.

Professor GOODHART said that Mr. Schwartz's references to the Company Law Revision Committee made him feel some hesitation in acknowledging that he had been a member of that Committee. He would like to congratulate Professor Sargent Florence on his paper. In it he had discussed the essential question concerning the control of business companies. As Professor Florence pointed out, originally it was possible to know who controlled these companies because the list of members was filed with the Registrar of Companies. In recent years a new practice of nominee shareholders had been introduced, so that in many cases it was impossible to know who were the beneficial owners of the shares. At first sight that might seem to be unfortunate; Professor Florence suggested that nominee shareholding was used frequently to conceal control, but in fact there was little evidence that it was used for that purpose. It was a particularly convenient method for business men and others to put shares into the name of a nominee.

In spite of Mr. Schwartz's comments, economists did give evidence to the Committee, and some of them suggested that nominee shareholding should be abolished. That would mean that every shareholder would have to state that he owned the shares in his own right. In a company with 120,000 shareholders that would mean 120,000 documents. It was felt, and it was stated in the Committee's report, that any possible advantage gained from more information would be outweighed by the trouble of having to file these documents; moreover it would be difficult to go through them when they were filed. What was recommended was much more simple; it was that anyone who was a beneficial owner of 1 per cent. of the shares of a company should file a statement declaring his interest. If his statistics were correct, however large the Company, there would at most only have to be 100 such statements filed.

He had some doubt whether knowing who had control of the shares would prove very much. He agreed with Sir Henry Clay that the most important question in modern companies concerned the position of the director. The directors planned the policy of the company. Whether it was possible to get statistics about directors was a difficult problem. One item of information which had been obtained concerned the age of directors in numerous companies, and the Committee reached the conclusion that as far as possible a director who was over 70 should not serve as a director unless there was some special reason. Then there was the other very important question which arose, concerning the payment of directors. Up to the present it had been difficult to know what they were receiving. Under the new Bill that would be stated in the accounts. In the payment of directors was found one of the great differences between the English Company and the American Company. In the United States the directors were not paid a salary, but only received a token fee for each meeting they attended. Their purpose in acting as directors was to make the shares of the company as valuable as possible. The English director was paid a salary, with the result, as Professor Sargant Florence pointed out, that he was more cautious, and less inclined to embark on enterprises entailing risk.

Finally, there was one point in company law which was of interest and which could be clarified by proper statistics. At present it frequently happened that a promoter when establishing a company sold property to the company and took debentures in part payment. Then if the company did not succeed he proceeded to exercise his debenture, and received his property back, with the result that the ordinary creditor was left with nothing. That was an unfortunate result of the law at present, but, strange to say, there were no adequate statistics which showed how common the practice was, and what the losses which the public sustained amounted to. Here, again, statistics would be of great value.

The Company Law Revision Committee had pointed out in its report that reform of company law had in large part been based, both in the past and in the present, on the need for more informa-

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tion, both to the shareholder and to the public. If the present Bill was duly enacted, as he was certain it would be, there would be much more information. But unless that information was carefully analysed it would not be of great value, and that was why the success of the new company law would depend to a great extent on the work that economists, like Professor Sargant Florence, and statisticians would do in analysing the reports which would become available for careful study.

Dr. HERON said that the data on which the paper was based were taken from the *Stock Exchange Year Book*, 1935–36, ten years ago, and it was rather unfortunate that it should be brought into the light at this particular time when there was a possibility that "one main obstacle to the discovery of the true disposition of ownership," the nominee shareholder, might at least be partially removed. It was promised in the King's Speech that a Company Law Amendment Bill would be introduced during the present session of Parliament. The Cohen Committee, upon the report of which the Bill would no doubt be based, made drastic recommendations as to nominee shareholding. If these recommendations became law he hoped that Professor Florence would be encouraged to attack the problem anew on the wider information then available, and that he would get the necessary financial assistance to enable him to do so, because it would be a big problem.

There was one other point in the paper to which he would like to refer, viz. the question of directors' qualifying shares. This illustrated some weaknesses of both method and material. First of all, Professor Sargant Florence's investigation was based on 10 per cent. of a certain group of companies, 436 in all, and of these, 121 had to be omitted because the necessary details were not shown in the *Stock Exchange Year Book*. That information could easily be obtained by reference to the Articles of Association of the missing Companies filed at Somerset House so that the sample could be made complete and more satisfactory. Qualifying shares, however, provided a very poor index of control, because a director was not required to be the beneficial owner of his qualifying shares; he might be a mere nominee. On the other hand, a director might choose to register in his own name only his qualifying shares, and to place in the name of a nominee any other shares in the company which he held. It should be made clear that the Companies Act itself did not require a Director to have any qualifying shares; that matter was left to the action of each individual company, and it took that action by adopting certain Articles of Association.

Mr. K. L. COHEN said that it did not always matter, when locating the control of a company, to know the percentage of shares held by the controlling group. If the rest of the shares were widely dispersed and were temporarily held as opposed to permanently held, that is, constantly changing hands, it was possible that a much smaller percentage, perhaps only 5 per cent., of the voting rights of the Company might in fact give control of policy to the group. The only way to find out to what extent control was concentrated (he was not quite sure whether it could in fact be done) was to attend company meetings at which decisions were taken, and to count the percentage of votes actually cast that were held by the controlling group. In some cases only a small percentage could be decisive where a large percentage of voting capital was widely held.

He wondered whether the underlying thesis could be shown to be true, that there was a correlation between enterprise on the one hand and, on the other, the degree of concentration of control. He did not know how enterprise could be defined, but if any accepted definition of enterprise was taken, one could see whether there was a correlation between that and any agreed definition of control. He did not think it could be agreed that it was necessarily enterprising to follow a conservative policy with regard to dividend, nor was it more enterprising to re-invest profits in the same industry when there might be better opportunities in other industries.

Another difficulty, even taking the paper as it stood, was that everyday forms of organization might be formed practically *ad hoc* when a vital issue arose. For instance, there was the case of the Peruvian Corporation debentures; when a reorganization of capital was suggested, an outside person, through a leading financial paper was able to get sufficient support from other debenture holders to get that policy reversed at a time when it looked as if the outside interests, being so widely dispersed, would not be likely to oppose the scheme effectively. Also, there was the fact that shareholders very often asked their stockbrokers for advice regarding the policy which a firm pursued. For instance, in the case of the nationalization of the railways the share-

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holders received a circular from the Companies asking whether they agreed to the prospective nationalization or not, and they asked their stockbroker whether he thought it was worth their while to oppose it. That was a line which might be followed up that there were other means of organizing shareholders.

Table VII showed the percentage of the voting capital held by the directors; it would be interesting to see also the percentage of voting capital held not only by the directors themselves but that held by the directors together with that held by companies in which the directors were interested and by their families, which would show much more clearly the degree of ownership of the company by the management.

One minor point which he would like to raise was that he did not know if Members of Parliament were included among the "guinea-pig" group of directors, but very often they were appointed to the boards of companies not perhaps to represent the company in the House of Commons but, at least, to see that their interests were not completely neglected there. It would be interesting to see the percentage of Members of Parliament who were members of the boards of a large number of companies and who did, in fact, see that the interests of those companies were safeguarded in parliamentary legislation.

There were very many wider issues of policy which could be investigated along the lines which Professor Florence had started. It seemed this was a very small initial step, although he thought it was an important one both statistically and economically as well as from a historical point of view.

The PRESIDENT said that he had been extremely interested in the paper given by Professor Sargant Florence. He thought he personally was under every form of condemnation mentioned. As a director he did not see any necessity to satisfy the curiosity of other people as to the amount of his wealth: that was a form of modesty a little trying to the statistician, and it was one of the reasons why it was so difficult to get precise information as to control. The sole reason why he disguised the amount of capital he held in his own company was because he saw no particular reason for satisfying other people's desire to inquire.

The whole subject was completely elusive. Nothing could be further from the mark than to think that it was possible to get any information on the subject of the control of policy. Professor Sargant Florence asked the question, "What has the control as shown here to do with the policy of expansion?" He could answer the question quite simply—nothing at all. No amount of investigation as to shareholdings would ever give any guidance as to the policy of companies. Mr. Cohen suggested that the control of companies' policy was directed at shareholders' meetings only when they were approaching bankruptcy. He was glad to say that at the last meeting of shareholders at which he presided he thanked the one "personally present" for coming! Shareholders were within their rights in attending meetings and asking for information, but the policy of no well directed company was determined at its annual meeting of shareholders, nor was it controlled by the shareholding at all. It was interesting that the trade of the country was in the main controlled by personalities: the commercial ability of people, and not shareholding, was the determining factor, and if the person who was in control because of his peculiar qualities for that post also happened to own a lot of the shares that was a great advantage. Of course, the entrepreneur capitalist could not live for long in this country: if he was at all successful he was bound during the course of his lifetime to go to the Stock Exchange, because if he did not do so and thereby obtain some public valuation of his shares he was subject not only to excess profits tax on the money he took out of the business, but on the money he left in it—a quite impossible position for advancement. No reserves could be made if 19s. 6d. in the £ tax was being paid. Then there was the problem of death duties. They were so high that no one at the present time dare risk not knowing the value of the shares of his Company. If there was not a public quotation then they were subject to the valuation of the Inland Revenue Department, the Estate Duty Office, which was a most perilous performance.

As a result of the system of taxation, therefore, it was inevitable that the capitalist entrepreneurs—for whom he had a high regard because they were the people who risked their own money and who added so much value and prestige to British industry—should now appear under the heading of a joint stock company.

There was one observation he would make with regard to the guinea-pig. The value to the

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joint stock company of the person who might not have a very large shareholding, who indeed might have a small shareholding, must not be forgotten. He might be very glad to receive the fee of £250, or he might (as a result of other aspects of his life) be able to supply the company with information of great value to the other directors in their deliberations. He sat on one board, at any rate, where there were what were called guinea-pigs, and they were of very great value because of their particular experience. It was a pity that they should be regarded as people to be reproached. The people to be reproached were those who were foolish enough in the past to run after titles and thought they could invest with greater security because a noble lord was in the chair.

Professor FLORENCE expressed his gratitude to the President for giving his experiences, and said that his full reply would be made in the *Journal*.

He subsequently wrote as follows:

As Sir Henry Clay surmises, I certainly did not mean to imply that there was any rule that twenty persons tended to hold 20 per cent. of the stock of a company. In fact, quite the opposite. I thought I had made it clear that the largest twenty shareholders holding 20 per cent. of the votes was a mere dividing line "ruling off" the companies with more concentrated voting power from companies with dispersed votes, or votes neither concentrated nor dispersed. And incidentally, when I said that three companies having 10 per cent. to 20 per cent. of voting power owned by twenty shareholders should be assigned neither to concentrated nor dispersed extremes, it is hardly fair to comment that they "happen to conceal the particular matters one wishes to measure." My primary aim was to measure the distribution of shareholdings—in large joint stock companies; if these three companies of intermediate type (I, IV and IX as stated in my paper) are added to the fifteen of more extreme type given in the Tables, only two companies (VII and XIII) are left out of the twenty where I suspect substantial concealment of the distribution. My suspicion had, however, been considerably alleviated by the discussion. It rested on the fear that the nominee device was used to conceal the degree of concentration of control. Both Professor Goodhart and Lord Woolton denied this, and I am relieved and grateful.

Sir Henry and other speakers were satisfied with their statement that the policy of a company is determined by the board of directors. I am not. My definition of control is not different to that of Berle and Means. They place it with the persons who have the real power to appoint the directors, and it is the power behind the throne that I am seeking, too. True, the board may be in the position of an absolute monarch with no powers behind his throne. But one cannot assume this. A concentration of large shareholders is very likely to constitute such a power; contrariwise, like many an absolute king's ministers, the executive officers and management may exercise the real power, particularly if there is no concentration of shareholding. I quite agree with Sir Henry that some types of shareholders, such as insurance companies and banks, though they hold large shares, may not want control. This is precisely the reason why I identified them with separate symbols "I" and "B." I also agree with his analysis of the Amalgamated Metal Corporation. The Appendix at the end of my paper showed that this is Company XVII, where I summed up the arrangement, as he does, as one of participation in control and co-ordination among the participants.

But I was, frankly, rather puzzled by Sir Henry's reference to the various histories of companies, as though the historical was in opposition to the statistical approach. I still do not see why it is not important to establish the statistical facts about the distribution of ownership as well as to find out the historical causes of such distribution. Indeed, it seems foolish to me to trace and interpret the historical causes of alleged facts (as so many books on industrial control have done) before you know what the exact facts are.

Lord Woolton stated that the trade of the country was in the main controlled by personalities. He would seem, with Berle and Means, to belong to the management control school that sees the end of domination by the owner of capital, in a "managerial revolution." He may be right; but I do not agree that this conclusion can be established without further investigation. Is it really to be accepted that "no amount of investigation as to shareholdings would ever give any guidance as to the policy of companies"? If Company A were found on investigation to hold 51 per cent. of the shares of Company B, would it not suggest that the policy of Company B was subsidiary to that of the "Holding Company" A? And would not the same be virtually true (in view of Professor Penrose's calculation in the *Journal*, 1946, Part I) if Company A owned 41 per cent., 31 per cent., possibly 21 per cent. of Company B's stock, when all other shareholders held only very small proportions? And this virtual control of policy, true of a single Company A, may also take place if two or a few companies or persons hold between them a large proportion

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of voting stock while remaining holdings are dispersed. In practice there is no such rigid line between the legally recognized holding company where shares admittedly give control of policy, and similar concentrations of shares.

This leads me, finally, to thank Mr. Schwartz for stressing that when the joint stock company is called less of an economic device than a legal entity, it does not dispose of the fact that the company is an astounding economic reality hitherto amazingly neglected by economists and statisticians "passing the buck" to the lawyers.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Jose Antonio de Artigas.
Robert Charles Athol.
Ronald Gordon Barley.
Lloyd Elgar Bell.
P. Beynon, B.A.
Harold Leslie Birbeck.
Charles Henry Bowers.
Edgar Ashcroft Bowes, B.Sc.
George Edward Pelham Box.
Leslie Norman Brook.
Kevin Browne.
Rose Olga Cashen, B.Com., Ph.D.
George Stephen Huntingdon Caston.
Kenneth John Clark.
Samuel Harrison Clarke.
Francis Arthur Cockfield, LL.B., B.Sc.
Reginald Harry Cooper, M.A.
Wilfred Rodney Cousins.
Donovan Cox.
George Harold Cox.
Francis Peter Cullen.
Edwin George Davy.
Joseph Gilfrid Day.
Arthur Denis Denton.
M. Ziaud Din, M.A., Ph.D.
Palahendi Hewage Diananda.
Harold Beddows Dunkerley.
Michael James Farrell.
Eric Richard Leman Fitzpayne, B.Sc.
Charles Ian Kennerley Forster, F.I.A.
Joseph Freud.
Vasant D. Gangolli.
Peter Waters Glassborow.
Francis Grant.
Robert Walker Gray.
William Keith Hancock.
James Austin Heady.
Melville Rees Hopkins, M.Sc.
Philip Lionel Ives.
Daniel Thomas Jones.
Salem Hanna Khamis.
John Clement Koop.
Saleh Abdul Amir Kubba, B.A.
Morton Kupperman, B.Sc.
Kenneth Lacey.
Everett Vernon Lewis, S.B., Ph.D.
Donald Erskine Locke.
Laurence Herbert Longley-Cooke, M.A., F.I.A.
Alistair Bruce MacColl.
Henry McCormick.
David Gardner McKelvie.
Arthur Hedley Marshall.
Alexander Winand Johan Mayer.
Alfred Hallett Milnes.
Michael Joseph Moroney, B.Sc.
A. N. Krishnan Nair.
Henry Desmond Patterson.
P. S. Bhaskaran Pillai.
Dennis Rouse Read.
John Desmond Richards, B.Com.
Alphonso D. Roach.
John Wentworth Rodgers.
James Hately Seddon.
Mohinder Singh, M.A., Ph.D.
Alan Buchanan Carrick Smith, M.A.
Kenneth Vernon Smith, B.Sc.
Raymond Stanley Smith.
Richard Benson Stalbow, B.Sc.
Roger Jean Gustave Steylaerts.
Reginald Frank Tasker.
Albert Jesse Thayre, M.B.E.
Herbert Arthur Thomas.
H. W. Turl, B.A., B.Sc.
Khushiram Nehhraj Vaswani.
Charles Cockerill Walmsley.
George Welch.
Owen George Weller.
Kenneth Alfred Coe Wheeler, F.I.A.
Gwylmor Prys Williams.
Arthur Stanley Willatt.
William Arthur Wilson.
Donald Richard Woodgate, M.Com., F.I.A.
Ralph Lyndal Worrall.
Terence Charles John Young.

Corporate Representatives

Alan Kingsley Chappell, *representing* McCann-Erickson Advertising, Ltd.
Leslie Charles Jones, *representing* Associated British Oil Engines, Ltd., and British Oil Engines (E), Ltd.
Fred Lambert, B.A.(Com.), *representing* Market Research Department, Co-operative Wholesale Society, Ltd.
Launce McMullen, *representing* Arthur Guinness, Son & Co., Ltd.
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Statistical Aspects of Demobilization in the Royal Navy

By John Wishart, D.Sc., F.R.S.E.

[Read before the Royal Statistical Society, December 19th, 1946, Dr. E. C. Snow, C.B.E., Ex-President, in the Chair.]

Introduction

Strictly speaking, it is not correct even now to speak of Demobilization as having taken place. In Command Paper 6548, entitled "Reallocation of manpower between the armed forces and civilian employment during any interim period between the defeat of Germany and the defeat of Japan," it was stated that general demobilization "cannot take place until the end of the war against the Axis Powers and their total defeat throughout the world. The plan set out in this paper is framed on the basis that the war against the Axis Powers is one war and that hostilities will first end in Europe, and it relates solely to the interim period between the defeat of Germany and the defeat of Japan. It is governed by the paramount consideration that there can be no break in the war effort after hostilities cease in Europe, and that in association with the other Allied Powers at war with Japan there must be the maximum deployment of the forces needed to bring complete and final victory at the earliest possible moment. It follows that in the interim period the problem will not be one of demobilization, but of reallocation of manpower between the Forces and industry in order best to provide for the requirements of the changed situation."

It transpired in due course that the change was to be effected by a *reduction* of the numbers in the Armed Forces, and a scheme was devised, about which more will be said later, to *release* those men and women who were surplus to the new requirements. In the event, the period between the defeat of Germany and the defeat of Japan proved a short one, but even so general demobilization is a process which takes place on the official declaration of the end of the period of emergency, done by Order in Council, at which period the mobilization of retired and reserve officers, recalled pensioners, reservists, retained continuous service personnel, personnel volunteering or called up on "war only" engagements, etc., is automatically cancelled, and the Armed Forces are reduced to their regular elements. This stage has not yet been reached, but in the meantime it was obvious that releases could proceed at a much faster rate than was originally anticipated, since military requirements were reduced to the level required for security and for seeing that the terms of surrender were implemented. Reallocation of manpower, therefore, may be regarded as the method by which demobilization will be eventually achieved in an orderly fashion, and no purist objections need be raised to the use of the term "demobilization." It soon, in fact, crept into general use.

Statistics and Manpower Budgets

The war was more "total" than any in which this country has previously been engaged. It was found necessary to develop the statistical services of Government to the point where strict account could be made of all activities conducing to a successful mobilization of effort for the prosecution of the war. This is particularly notable in the fields of production and manpower. The device of a Manpower Budget is one in which a strict account-keeping is done of the manpower (and womanpower) of the Nation, certainly between the ages of 14 and 60, in order to ensure that the right numbers are assigned to the appropriate spheres of activity. Indeed, in those days when for reasons of security Departmental estimates were presented to Parliament in "token" form, and when the financial cost of the various services had to be subordinate to the paramount necessity of fighting out the war to a successful conclusion, the Manpower Budget of the Ministry of Labour and National Service may be said to have been of as great, if not greater, importance than the financial Budget. There were no "token" Manpower Budgets. Now when the time came for Reallocation of Manpower, the Manpower Budget increased, if anything, in importance, and the need for accurate statistics remained. Much of the work done had necessarily remained secret during the war, but the veil was partly lifted when Command Paper 6564, entitled "Statistics relating to the War Effort of the United Kingdom," was issued in November

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TABLE 1.—*Age and Service Group Numbers showing the Rela*

MONTH OF COMMENCE MEN

Year Born.	1939		1940						1941						1942			
	Sept. Oct. and earlier	Nov. Dec.	Jan. Feb.	Mar. Apr.	May Jun.	Jul. Aug.	Sept. Oct.	Nov. Dec.	Jan. Feb.	Mar. Apr.	May Jun.	Jul. Aug.	Sept. Oct.	Nov. Dec.	Jan. Feb.	Mar. Apr.	May Jun.	Jul. Aug.
1895 and Earlier	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
96	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
97	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
98	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
99	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1900	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
01	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
02	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
03	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
04	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
05	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
06	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
07	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
08	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
09	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1910	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
11	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
12	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
13	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
14	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
15	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
16	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
17	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
18	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
19	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1920	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
21	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
22	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
23	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
24	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
25	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
26	.....	.....	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
27	.....	.....	.....	.....	.....	.....	.....	.....	42	43	44	45	46	47	48	49	50	51
28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	49	50	51	52
29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1930	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

NOTE 1.—*Priority for men of 50 and over.* The Table places all men born in 1895 or earlier in Group I. On 1st January, 1946, all men born in 1896 and on 1st January, 1947, those born in 1897, will be given Group I priority, and so on.

1944, while in the particular case of the Armed Forces further particulars of the past and prospective strengths of the various arms, together with detailed particulars of the releases scheduled to take place over a period of twelve months following the defeat of Germany, were announced by the Minister of Labour and National Service on October 2, 1945.

A further aspect of the statistical problem concerned the need for the Service Departments to keep records of serving personnel for a hundred-and-one uses, not the least being the necessity to provide information to enable the Government's Reallocation of Manpower Scheme to be put into effect within each Service. It is the object of the present paper to comment on the Scheme from the point of view of the statistical problems thrown up for solution, and opportunity will be taken to describe, in particular, the records of the Naval Personnel Statistical Section in the Admiralty, and the part they have played in the operation of the Release Scheme. A further question, not so much of statistics proper as of calculation, concerns the need to determine, in

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Relative Order of Release from the Armed Forces

MENT OF WAR SERVICE.

1942		1943						1944						1945					
Sept. Oct.	Nov. Dec.	Jan. Feb.	Mar. Apr.	May Jun.	Jul. Aug.	Sept. Oct.	Nov. Dec.	Jan. Feb.	Mar. Apr.	May Jun.	Jul. Aug.	Sept. Oct.	Nov. Dec.	Jan. Feb.	Mar. Apr.	May Jun.	Jul. Aug.	Sept. Oct.	Nov. Dec.
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
.....	.....	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
.....	.....	.....	.....	.....	.....	.....	.....	63	64	65	66	67	68	69	70	71	72	73	74
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	70	71	72	73	74	75

NOTE 2.—War service, in general, means whole time service in the Armed Forces, since 3rd Sept., 1939, which counts for Service pay. Breaks in service in consequence of temporary release, etc., do not count as war service, and may result in a man being placed in a later Age and Service Group.

terms of numbers of men and women required in the Service, the consequences of a given scale of Fleet and attendant Services, after this has been worked out by the Planning Authorities following directives issued by the Chiefs of Staff. This work has always been important for manning purposes; it now also plays a part in the Release Scheme, since until it is known how many men and women are required it is impossible to say how many can be released, after taking account of fresh allocations of manpower continuing to be made, and of the ordinary wastage which goes on.

Such personnel statistical work is probably fairly typical of what goes on in many Government departments. There is a good deal of "bread and butter" work, and only rarely do opportunities occur for spectacular work of an interesting mathematical or theoretical statistical nature. The work is all of it, however, very necessary, and a certain measures of skill and experience is required in the staffs engaged, if the best return for the expenditure of time and money is to be gained.

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The Age and Service Group Number

Command Paper 6548 laid down that "reallocation" must be governed by two main principles: (*a*) military requirements must override all other considerations, and (*b*) the arrangements for the release of men from the Forces must be such as will be readily understood and accepted as fair by the Forces, and must not be too complicated for practical application. The first principle has been ever present to the Service authorities, although there was no hesitation in re-assessing military requirements in a downward direction following the defeat of Japan; it may not, however, have been fully allowed for by the more vocal of the elements clamouring for speedy demobilization. As regards the second principle, this has certainly been achieved; possibly, in the opinion of some, the scheme has been over-simplified in its public presentation to the extent that a good deal of explanation was necessary as to why the same groups were not being released at exactly the same time in all three Services.

It was decided that "men will be released by release groups based on a combination of age and length of war service, except that men of 50 years of age and over will be treated as a priority class to be released if they so desire before other men." The same arrangements applied to women, with the addition that married women had priority over all others, if they so desired. The combination of age and length of war service was on the basis that two months of service was equivalent to one additional year of age. This gave rise to the widely popularized "Age and Service Group Number." This is illustrated (Table 1) by the Table in the "Release and Resettlement" booklet issued to serving members of H.M. Forces, from which it was very easy for a man or woman to work out his own Group Number. This number is the sum of two numbers, $x + y$, where x is obtained by adding 7 to the last two figures of the year of birth (deducting 100 for those born before 1900), while y is the serial number of the two-month period within which the date of enlistment fell, beginning with the period September–October, 1939, as period 0. The exception is that all those born 1895 or earlier were assigned to priority group 1 (women with marriage priority were assigned by the Admiralty to a group 0). Periods of broken service, unpaid leave, etc., were reckoned by deduction of the required number of two-month units. The group number is a quantity, therefore, which remains unchanged after calculation at the outset, so long as the service remains continuous, and can be inscribed in the Serviceman's documents and incorporated on his record card, in contradistinction to a system of "points" which can be earned by length of service and other considerations, and which will therefore rise as the service goes on.

It is important, however, to note that there is bound to be an uneven distribution of personnel within the groups both within any one service and between one service and another. Group 1 consisted of all men born 1895 or earlier, and was much the largest group of Naval ratings and Royal Marine other ranks until down to the middle twenties, and for Naval officers was several times the size of its nearest rival. This was due to the inclusion of recalled pensioners and re-servists and of recalled or re-employed retired officers, of whom large numbers were by mid-1945 over 50 years of age. Group 2 only had a brief existence prior to January 1, 1945, i.e. before the release plan came into effect; while Group 3, which has since disappeared, consisted of those born in 1896 who joined up at the outbreak of war. On the other hand Group 27, the biggest in the Navy for male officers and ratings alike out of the first fifty, covered a wide range of men, from those born in 1896 who joined in September–October, 1943, to those born in 1920 who joined at the beginning of the war. To some extent the way in which the group number is calculated creates similarities in the distributions as between the different services, but on the other hand differences of manpower priorities leading to a direction of the call-up at any one time to one service rather than to another lead to differences. When, therefore, it also happens that a reassessment of manpower requirements for the Services (e.g. as at June 30, 1946) shows different rates of reduction for Navy, Army and Air Force from the peak figures in June, 1945, it is not surprising that the announced programme of releases should vary, as regards the group numbers to be reached, between the different services.

That the programme must also vary, in respect of group number, within a single service, may be illustrated by contrasting officers and ratings of the Navy. The frequency distributions of officers and ratings in the different groups before the releases started are shown in Fig. 1 and Table 2. Now it happened that on the average of all branches, the strengths were in the ratio

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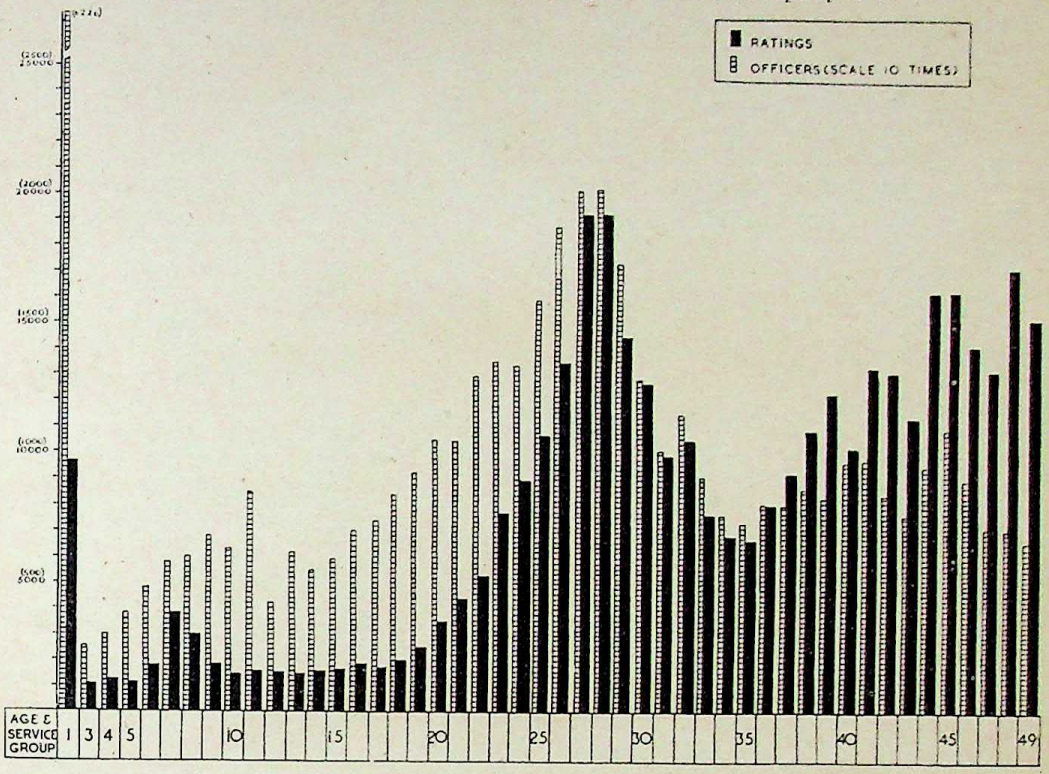
FIG. 1

Distribution of Officers and Ratings in Age and Service Groups up to 49



of one officer to ten ratings in June, 1945 (little different from pre-war days), and calculation of the requirements on June 30, 1946, also produced a ratio of one officer to ten ratings. Since wastage during the year, together with Class B releases (which will be discussed later), had been calculated on the basis of past experience to be roughly equivalent to the permitted fresh intake, it follows that the reduction in numbers between the strength in June, 1945, and the requirements figure in June, 1946, was a measure of the releases to be effected in Class A, i.e. the ordinary releases made in order of Age and Service Group number. The Minister of Labour and National Service announced on October 2, 1945, that the strength of the Navy would be reduced from 772,000 men to 400,000, i.e. to little more than half. Within this period the Navy could not, therefore, afford to lose more than half its officers. This factor conditioned the latest age and service group scheduled for release, on the average, by June, 1945. It was, in fact, stated on October 2 that the average level reached by the Navy would be:—

By December, 1945	Officers:	Group 20
	Ratings:	Group 31 (part)
By June, 1946	Officers:	Group 32
	Ratings:	Group 45

These figures were later materially revised.

It is of some interest to examine the nature of the "control" that was exercised in the matter from the beginning. Ignoring, for the purposes of a first broad survey, the differences between branches of both officers and ratings, let us choose a group of 2000 officers as a *unit*, with a corresponding unit of 20,000 ratings. Theoretical release by "units" is shown in parallel in the following table, based on the content of the various Age and Service Groups, but ignoring other considerations.

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TABLE 2.—*Distribution of Men in Age and Service Groups up to* 49

OFFICERS R.N. AND R.M.

Group.	Number.	Group.	Number.	Group.	Number.	Group.	Number.
1	6,226	14	545	26	1,883	38	872
3	257	15	592	27	2,333	39	840
4	298	16	705	28	2,247	40	972
5	386	17	746	29	1,739	41	982
6	480	18	843	30	1,286	42	858
7	580	19	928	31	1,012	43	777
8	600	20	1,055	32	1,157	44	963
9	574	21	1,027	33	915	45	1,096
10	629	22	1,294	34	766	46	894
11	655	23	1,354	35	740	47	723
12	621	24	1,342	36	621	48	715
13	615	25	1,594	37	810	49	670

RATINGS R.N. AND OTHER RANKS R.M.

Group.	Number.	Group.	Number.	Group.	Number.	Group.	Number.
1	9,650	14	1,607	26	13,568	38	10,918
3	1,055	15	1,640	27	19,289	39	12,374
4	1,227	16	1,872	28	19,504	40	10,135
5	1,142	17	1,756	29	14,572	41	13,614
6	1,802	18	1,995	30	12,747	42	13,243
7	3,835	19	2,462	31	9,985	43	11,425
8	2,987	20	3,524	32	10,551	44	16,353
9	1,813	21	4,818	33	7,754	45	16,367
10	1,457	22	5,222	34	6,867	46	14,198
11	1,583	23	7,715	35	6,713	47	13,265
12	1,534	24	8,970	36	8,072	48	17,360
13	1,422	25	10,661	37	9,348	49	15,030

NOTE.—The above figures (as published in *Hansard*) refer to June, 1945. The text refers to Group 27 for ratings as having the highest number. This was true for the count made at a somewhat earlier date.

The two parts into which the Table is divided correspond only very roughly with releases for the second half of 1945 and the first half of 1946 respectively (for example the 9th unit has not been split, and volunteers for continued service have been ignored). The Table is, therefore, illustrative only of the comparative positions of officers and ratings, and is in no sense a time-table of releases actually effected.

The first startling fact to note is the disproportionate number of officers in Group 1. Had release taken place strictly by units, for officers and ratings alike, and had there been no volunteers for continued service, we should have found ratings being released in Group 23 while Group 1 for officers was still being cleaned up. Fortunately, perhaps, for the impact of this on the service, the proportion of officers accepted for retention at their own desire was such as to redress the balance considerably. No less than $21\frac{1}{2}$ groups of ratings correspond at this end of the Table to the first group of officers (note that Group 2 is non-existent). The officers catch up rapidly after this down to the ninth unit; from the fourth to the ninth units (inclusive), $8\frac{1}{2}$ groups of ratings correspond to $18\frac{3}{4}$ groups of officers. This position is reversed in the second half of the table, in which from the tenth to the seventeenth units (inclusive), 14 groups of ratings correspond to 10 groups of officers. Broadly, what this amounts to is that for the *same* proportion of officers as of ratings released within a given time (and it would not be possible to release a higher proportion), Groups 1–31 for ratings are equivalent to Groups 1–21 (part) for officers, and Groups 1–45 for ratings are equivalent to Groups 1–31 (part) for officers.

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TABLE 3

Unit.	Officers. A. & S. Groups.	Officers. Number of Groups in Unit.	Ratings. A. & S. Groups.	Ratings. Number of Groups in Unit.
1	1 (first third)	$\frac{1}{3}$	1 and 3–7	6
2	1 (second third)	$\frac{1}{3}$	8–18	11
3	1 (remainder)	$\frac{1}{3}$	19–23 (half)	$4\frac{1}{2}$
4	3–7	5	23 (rem.)–25 (half)	2
5	8–10	3	25 (rem.)–26	$1\frac{1}{2}$
6	11–13	3	27	1
7	14–17 (first third)	$3\frac{1}{3}$	28	1
8	17 (rem.)–19 (two-thirds)	$2\frac{1}{3}$	29–30 (first third)	$1\frac{1}{3}$
9	19 (rem.)–21 (two-thirds)	2	30 (rem.)–31	$1\frac{2}{3}$
1–9	1–21 (two-thirds)	$19\frac{2}{3}$	1–31	30
10	21 (rem.)–23 (first third)	$1\frac{2}{3}$	32–33	2
11	23 (rem.)–24 (two-thirds)	$1\frac{1}{3}$	34–36	3
12	24 (rem.)–25	$1\frac{1}{3}$	37–38	2
13	26	1	39–40 (half)	$1\frac{1}{2}$
14	27	1	40 (rem.)–41	$1\frac{1}{2}$
15	28 (three-quarters)	$\frac{3}{4}$	42–43 (half)	$1\frac{1}{2}$
16	28 (rem.)–29	$1\frac{1}{4}$	43 (rem.)–44	$1\frac{1}{2}$
17	30–31 (two-thirds)	$1\frac{2}{3}$	45	1
10–17	21 (rem.)–31 (two-thirds)	10	32–45	14
1–17	1–31 (two-thirds)	$29\frac{2}{3}$	1–45	44

This difference between officers and ratings was inevitable, and was foreseen. There was no departure from the principles of the release scheme. Command Paper 6548 stated: "Owing, however, to military considerations, release will necessarily proceed at different rates in the different Services. It will be necessary in some Services to deal separately with the several branches and possibly with trades and ranks (or ratings) in those branches." The case which has been illustrated is one in which the two classes proceed at approximately the *same* comparative *rates* of release, but these look different when expressed in terms of the age and service groups covered in the process. In effect, of course, this means that a rating in Group 25 got out in the autumn of 1945, while a man of the same age and service who had been promoted to commissioned rank from the lower deck was not released (on this programme) until early 1946.

Similar considerations apply to the different branches of both officers and ratings. The distribution in age and service groups was by no means the same for all, and thus even in the cases where the *rate* of reduction could be the same all round, the Age and Service Groups reached were not the same. Added to this, there were cases where the average rate could not be attained, including categories whose activities were necessary for the operation of the accelerated release scheme. It is for this reason that the published group numbers to be reached by given dates have been emphasized as averages. The Ministry of Labour and National Service issued a statement on the subject on October 16, 1945, and later the First Lord answered a question in Parliament to the same effect. These pointed out, with reference to the published group numbers, that the dispersal of some rating groups (see later for definition) will have proceeded beyond these numbers, while other branches, particularly the regulating, engine room, sick berth, and supply and secretariat branches, will not have reached them. For officers the dispersal of engineers, supply and secretariat and some categories of warrant officers was to be slower than indicated by the average numbers published, while for W.R.N.S. ratings release would be slower than average in the supply and secretariat, administrative, switchboard operator and mechanical

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transport driver categories. It will not be lost on Fellows of the Society that, in view of the well-known definition of an average, there were compensating categories of men and women whose release proceeded down to Group numbers beyond those published.

Rating Groups

There are many hundreds of kinds of ratings, both substantive and non-substantive, in the Navy. In some of these, e.g. Ordinary Seaman, it was easy to contemplate the release of large numbers as the Navy ran down. Fresh recruitment and the normal periods of training served to inject new blood to keep the balance. In others, particularly the various kinds of technicians, long periods of training are necessarily involved, and while they also were not in general required in such large numbers with a smaller Fleet, the numbers likely to be available at any future date had to be looked at with a critical eye. It has already been stated that it was not possible to release from all branches of officers and ratings at the same rate. In order, however, to reduce to a minimum these inequalities in rates of release, ratings were grouped in just over 300 *Rating Groups*, comprising ratings R.N., other ranks R.M. and W.R.N.S. ratings. Officers were also divided into "officer categories," a thing which was particularly important for the very large Executive and Special Branch. To illustrate, Rating Group No. 1 is a part of the Seaman Branch consisting of seamen in the rates Chief Petty Officer, Petty Officer, and Temporary Acting Petty Officer (Submarines). With rare exceptions, as when only part of a rating group could be released, it was then very simple to order the release of a particular set of rating groups in a particular Age and Service Group, or set of groups. It was necessary, however, not only to set out for the benefit of the Fleet the content of each rating group in serial order of the group, but also to compile a list of all rates in alphabetical order, giving the rating group against each, in order that the release orders should be applied only to those to whom they were intended to refer. Thus, referring again to Rating Group No. 1, if we turn up "Chief Petty Officer" and "Petty Officer" in the alphabetical list, we find that, in addition to those in Rating Group 1, there are 40 other kinds of Chief Petty Officer comprised in 33 Rating Groups other than 1, and 64 other kinds of Petty Officer comprised in 56 Rating Groups other than 1. The order for the release of Rating Group No. 1 would not apply to the rates shown in other Rating Groups, for whom the Age and Service Group released might well be different. On the other hand, there is only one rating of Temporary Acting Petty Officer (Submarines). In contrast to this complex case we have Rating Group 3, much the largest in the Navy, and consisting of Able Seaman, Ordinary Seaman, Boy 1st Class and Boy 2nd Class. The only ratings of this kind not comprised in Rating Group No. 3 are certain Able and Ordinary Seamen in Groups 10, 12, 52 and 221 (Mine Watchers, Harbour Defence, Radar and Meteorology), together with Ordinary Seamen in Group 6 (Patrol Service) and Able Seamen in Group 200 (Combined Operations).

Statistically, the institution of rating groups made things simpler, but on the other hand gave the statisticians a great deal to do. Once the rating group had been worked out for each man and inscribed on his record, it was possible, and indeed necessary, to compile great two-way frequency tables to show the distribution in age and service groups of the men (or women) in each rating group. As there are something over 300 rating groups, and the Age and Service Groups now reach into the seventies, the results of this work were somewhat voluminous, although the results were simplified by having separate Tables for men and women. The Tables were valuable, however, in that they enabled an assessment to be made of the numbers in each rating group that could be spared during any particular release period, and consequently the age and service group to be reached in releasing that number. They also showed the "red light" at an early stage, for it emerged on inspection that if the age and service groups were to be kept as far as possible in step for the various rating groups, shortages in some groups in relation to requirements had to be made up by training and remustering of men and women from other groups in which there was a surplus. Like all strength tables of personnel, there was continual movement, and although for overall purposes outflow is balanced at any stage by intake to the agreed extent—intake exceeding outflow when the Navy was expanding to its maximum numbers, equalling outflow when it was stabilized, and falling far short of outflow now that numbers are being run down—it is important to note that in tables arranged by age and service group, demobilization releases lead to outflow at the top, ordinary invalidings, deaths and other wastage lead to wastage

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all the way down, while intake, which is preponderantly from the call-up of the eighteen-year-olds and young volunteers, comes in at the bottom. A further consequence of demobilization releases is the draining away of the higher ratings, since these will generally be older and of longer service, and this necessitates a continued programme of training and advancement to the numbers necessary.

A count, by age and service groups and by rating groups, was thus only a snapshot of the state of affairs at any one time, and soon became out of date. It was thus necessary to repeat the compilation at frequent intervals if an adequate check was to be kept on what was happening. This was done by analysing the outflow, whether of demobilization releases or of wastage, in terms of the age and service group and rating group shown on the record card, and doing the same for the new entrants. Thus, by a system of "offs" and "ons" it was possible to keep pace with demands, but even so, the amount of analysis work involved was considerable.

Class "B" Releases

It was stated in Command Paper 6548 that the Government Plan provided for two separate methods of selecting men for return from the Forces: "Those selected according to age and length of service will form one class (Class A), and those selected on account of their qualifications for urgent reconstruction work will form a second class (Class B)." It was laid down that the number of transfers in Class B should be small in proportion to those in Class A, in order not to detract to more than an acceptable extent from the general principle of release by age and length of service, and the Services worked to a 10 per cent. proportion (later increased where possible). The object was to obtain "key men," i.e. men belonging to particular occupational classes specified by the Minister of Labour and National Service as required for certain urgent reconstruction employments. They were mainly required to supplement the labour force available for building houses; in addition Class B was to include a limited number of individual specialists, for whose transfer application was to be made through Government Departments. Men in the desired occupations would, of course, be released in Class A, and effectively, therefore, the Class B arrangements involved a "dipping down" below the age and service groups released at any one time in Class A. Since the men concerned were getting out before their time they were subject to different conditions; in particular they were not to get the same amount of resettlement leave as the others, and powers of direction were retained over their civil employment. A programme of releases in Class B to the extent of 147,580 men and women was announced on October 2, 1945, covering the three services. The big items were: block releases in building and civil engineering (60,000); industries ancillary to the foregoing, school teachers, and individual specialists (10,000 each); and underground coalminers (30,000); but provision was also made for university teachers and students, for members of the civil police forces, and for women in wool textile industries, laundries and certain essential services. The programme was modified from time to time in relation to needs; for example, the "ancillary" target was later raised, and women were brought into the picture much later than men.

What chiefly concerns us in this paper is the method whereby these releases in Class B were effected. Individual specialists were named by the Ministry of Labour, and there was also the "nominated block" category covering, for example, school teachers listed by education authorities and policemen listed by the Home Office. In all these cases the men could readily be identified and the processes of release put in motion. But in the great majority of cases of block release, the required numbers were divided into quotas to be met by the Service Departments in given intervals of time. It was arranged that in each case the occupational classification code would be used. This consists of a (generally) two-letter code for the *industry group* and a decimal subdivision of a (generally) three-figure code for the actual *occupation*. The system is one used by the Ministry of Labour, and from an early stage of the war the code numbers were supplied by the Ministry of Labour for the new recruits who were entering. In other cases the pre-entry occupation was in general known. The coded occupational classification is recorded on the Service record card, and the Admiralty arranged to duplicate the entire index in order that there might be one index which could be filed in occupational order. Details of the recording work are deferred to the next section; for the present it is enough to say that when a demand came in for a certain number of men in the building and decorating industry (group code AB) who

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were bricklayers (general hand) (classification code 003.2), it was possible to go to the section of the index indicated by the code numbers, and deal with the possible "population" at once. The Class B scheme did not really get started until July 16, four weeks after the Class A releases began; in addition the time taken to get orders out to the Fleet had to be allowed for. It was, therefore, no use nominating men for block release who were in the early Age and Service groups, since the likelihood was that they would be out in Class A before they were reached for Class B, or that, if that stage had not been reached, they would be unlikely to accept release in Class B if by waiting just a little longer they could get out in Class A. A starting-point had, therefore, to be fixed. To begin with, this was Group 21, but later developments, which not only led to releases being speeded up, but at the same time led to varying Class A targets, in respect of Groups to be reached in the various rating groups, made the problem more complex. By late 1945 no one nominated was in Group 31 or below, but there were a number of different starting-points depending on the rating group. In the end, a list was prepared of men in order of age and service group to an extent sufficient to allow for adjustments, refusals, withdrawals, etc., and still leave enough to meet the quota (provided there was that number of men in the Navy in the required occupation). Like Class A, there was the "military necessity" clause under which it was stated that no man would be realeased if his retention was considered necessary on military grounds; at the same time it was stated that every effort would be made to release men in their turn. Men in Class B were already out of turn; despite this, every endeavour was made to deal with them strictly in their age and service group order. There were, however, shortages in certain rating groups which, at any rate for a time, led to Class A releases in those Groups not proceeding to the same age and service group by a given time as in some others. This was reflected in Class B, not only by having the starting-point earlier, but in some cases by a restriction on the number in a particular quota that could be released in a particular rating group. The lists, therefore, stated the rating group, and required a first examination from this point of view. They had to go to the Depots, in order that the ship on which the man was serving could be inserted. When finally agreed by all concerned, the lists were promulgated by Admiralty Fleet Order, which started off by referring to the Admiralty's Release Instructions, and then gave the description of the recorded pre-entry occupation, both in general terms and by code, and added domicile (where applicable). It was then stated that the individuals in the appended lists (officers or ratings, men or women) had been nominated for release in Class B.

The statistical machine was not concerned again, in general, until reports of actual releases came in. But various things might happen in the ship or establishment. The nomination was brought to the attention of the individual. If he accepted release he was discharged to shore for release, and the fact reported. If he refused, he stayed where he was and the fact of refusal was reported. In addition, men who considered that they had been "overlooked" had an opportunity of representing that they considered themselves eligible for release in Class B according to the orders promulgated, although their names did not appear in the list. If the case appeared, *prima facie*, to be a good one, it was reported to the Admiralty, where it was either admitted, if a genuine case, or disallowed. Many men proved to be not within the selected classification, e.g. builder's labourer (before this occupation was chosen for Class B purposes) who thought he was covered when it was skilled builders who were wanted, or men who were properly classified but were so high in age and service group that they had not yet been reached.

Taken all in all, a great deal of work was involved on behalf of this fraction of the total number of releases; the great majority were, and continue to be, released in bulk in Class A. It can certainly be put to the credit of the Services that they have taken a great deal of trouble to identify the men and to try to get them out. Disappointments occurred, of course; men seemed at first to take a long time to make up their minds, and this, added to the time it took to get Fleet Orders round the world, led to the response by way of actual releases being at first disproportionately small by comparison with the numbers nominated. Then there were many refusals; it may interest Fellows to inspect the following two-by-two table, in which the numbers of builders and ancillary workers released, and refusing release, were compared for age and service groups under and over 31 respectively in the autumn of 1945. At that time it had not been announced that Group 31 would, on the average, be reached by December 31; the figure announced to the Fleet was around 26. At this stage, too, time had not permitted of more than a small fraction of results to be achieved from the very large number of orders which had gone out.

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TABLE 4

Age and Service Groups.	Numbers Released in Class B.	Numbers Refusing Release.	Total Responses.
Up to 31	328	633	961
32 onward	396	234	630
All Groups	724	867	1,591

Personnel Record Cards

Under the Second Sea Lord, responsibility for the demobilization work has rested on the Deputy Chief of Naval Personnel (for co-ordination of the work of the various Officer Appointing Authorities) and on the Assistant Chief of Naval Personnel (who is also Director of Personal Services), who set up a special Demobilization Division and is specially concerned with ratings. On the statistical side, reliance was placed on the civilian-manned Naval Personnel Statistical Section, which is responsible to the Secretary of the Admiralty. The work this Section had to do was of two kinds: first statistics had to be prepared, and kept up to date, of the numbers in the various age and service groups, rating groups and occupational classifications, in order to enable policy decisions to be taken, programmes of release to be formulated, retraining and remustering to be done, and assessments to be made of the required continued intake, which was part of the plan in order to increase the releases in Class A and to compensate for the transfers in Class B. Secondly, the Section was relied on to provide statistics of the numbers released, and of the consequent changes in strength. The method was to extend the record card system, which had been in operation since 1918, so as to cope with the new problems. The punched card system (Hollerith) of the British Tabulating Machine Company is used, and a survey will now be made of the present operations.

For each new entrant an index card (S.160) is furnished by the Entry Establishment. It is useful to keep this as a visible index record, and to bring it up to date when changes are notified. But the first step in mechanical recording is to punch a card of the form shown (with key) in Fig. 2, supplemented, however, by the addition of particulars in regard to date and type of entry, e.g. volunteer, called up under the National Service Acts, transferred from another Service, returned from temporary release, etc. From this card the required number of cards is mechanically reproduced as illustrated for the indexes which are maintained. These are three: one for the "maintenance" file, which is held in official number order and continuously fed with the new cards, and two for the "statistics" files. In these latter "Active Service" and "War Only" are separate, transfers only being necessary when a time-expired Active Service rating does not re-engage, and when a "War Only" rating signs a regular engagement. One file is held in official number order within rating groups, while the other is similarly divided by occupational classification. The files are held in their existing state for a period of one month, during which the first can be used, among other things, for producing an up-to-date rating group and age and service group count, and the second for the continuous identifying and listing of names for Class B releases. These are the files which are available for the production of any other statistics required, except that the ordinary strength statements are usually prepared from month to month by a system of "ons" and "offs," i.e. by taking account of new entries, discharges and changes, an all-in count being allowed for as a check at about six-monthly intervals.

When the file cards have been prepared from the new entry card it is held until a full month's batch is complete; the cards are then sorted and counted to provide the "ons" for the strength statement, analysed by type of intake. They are then stored so as to be available at any subsequent time for examination.

The opposite process takes place with discharges, and is illustrated in Fig. 3 by means of a notification of a Class A release on Form S.161R. This form provides, outside the thick black lines, for basic information to enable the rating to be identified, while inside, a single tick in the appropriate square is all that is required apart from dates and home address. All demobilization information is incidentally provided for; release in Classes A or B, at home or abroad, etc., volunteer for retention, refusal of Class B release, and W.R.N.S. rating not taking advantage of priority in release as married woman. On the form being received and showing a release

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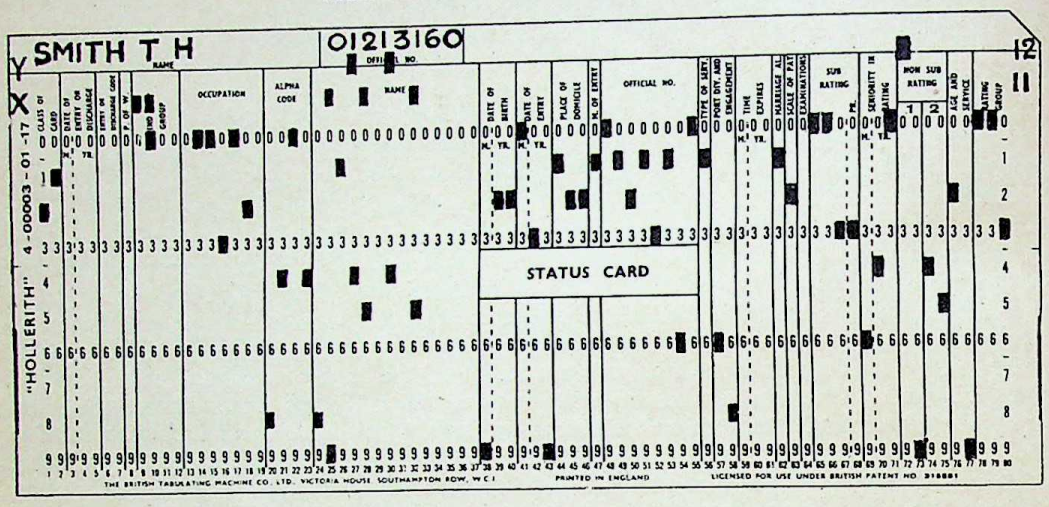
FIG. 2

Maintenance File Card—R.N. Rating



Columns	Description	Code	Decode or Remarks
1–2	Class of Card	21	Maintenance Index Card
3–5	Date of (*a*) Entry or (*b*) Discharge	—	Punched on (*a*) Entry Card or
6–7	(*a*) Entry or (*b*) Discharge Code	—	(*b*) Maintenance Card on discharge
8	Prisoner of War	—	Punched for Prisoners of War only
9–12	Industry Group	AB	Building and Decorating
13–19	Occupational Classification	00302	003·2 Bricklayer-General Hand
20–23	Name. Sorting Code	8404	Smith, T.
24–37	,, Alpha Code	—	Smith, T. H.
38–40	Date of Birth (Month and Year)	922	September, 1922
41–43	Date of Entry (Month and Year)	039	October, 1939
44–46	Place of Domicile	122	Bolton, Lancashire
47	Method of Entry	1	First Entry (as man)
48–55	Official Number	01/213160	JX 213160
56	Type of Service	1	General Service
57–58	(*a*) Port Division and (*b*) Class of Engagement	68	(*a*) Chatham (*b*) "Hostilities only"
59–61	Date of Expiration of Engagement	—	Not applicable to "Hostilities only"
62	Marriage Allowance	1	Wife and one child
63	Scale of Pay	2	1925 Rates
64	Examinations Passed (or special qualifications held)	—	Nil
65–67	Substantive Rating	003	Able Seaman
68	Progressive Rate	3	Over three years man's service
69–71	Seniority in Substantive Rating (Month and Year)	640	June, 1940
	Non-Substantive Rating		
72–73	(1) Primary or main	Y 9	Anti-Aircraft Rating 3rd class
74–75	(2) Secondary or subsidiary	45	Diver 2nd class
76–77	Age and Service Group	29	Age and Service Group 29
78–80	Rating Group	003	Rating Group 3=Able Seaman

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FIG. 3

Demobilization Card—R.N. Rating. (*a*) Report on Form S.161 R.—Release in Class A.

DUPLICATE

S.—161 R (REVISED MAY, 1945)	SURNAME*	CHRISTIAN NAMES (as recorded in Ledger).*	R 493296
	SMITH	Thomas H.	

1. RELEASED IN CLASS A:—
   In U.K. ☑ In U.K. while on temporary release ☐ Abroad ☐
   Abroad as Repatriate ☐ Abroad, having been entered abroad (including ratings entered locally) ☐
2. RELEASED IN CLASS B (BLOCK):— ☐ While on temporary release ☐
   Industry Group ..... Occupational Classification .....
   A.F.O. authorising release .....
3. RELEASED IN CLASS B (SPECIALIST):—
   In U.K. ☐ In U.K. while on temporary release ☐ Abroad ☐
   Authority for release .....
4. ACCEPTED AS VOLUNTEER for postponement of release when eligible for release in Class A ☐
5. ELECTED NOT TO BE RELEASED IN CLASS B (BLOCK):— ☐
   Industry Group ..... Occupational Classification .....
   A.F.O. authorising release .....
6. ELECTED NOT TO BE RELEASED IN CLASS B (SPECIALIST):— ☐
   Authority for release .....
7. MARRIED W.R.N.S. RATING ELECTED TO BE RELEASED IN AGE AND SERVICE GROUP when eligible for release as Married Woman ☐

SUBSTANTIVE RATING AND PROG. RATE.*	NON-SUB. RATING OR CATEGORY FOR W.R.N.S.*
A.B.	A.A.3. Diver 2.

PORT DIVISION & OFFICIAL NUMBER.*
C/JX 213160

LIST AND NUMBER ON SHIP'S BOOKS.*	NAME OF TENDER.*
52/H29	–

AGE AND SERVICE GROUP NUMBER*	RATING GROUP*
29	3

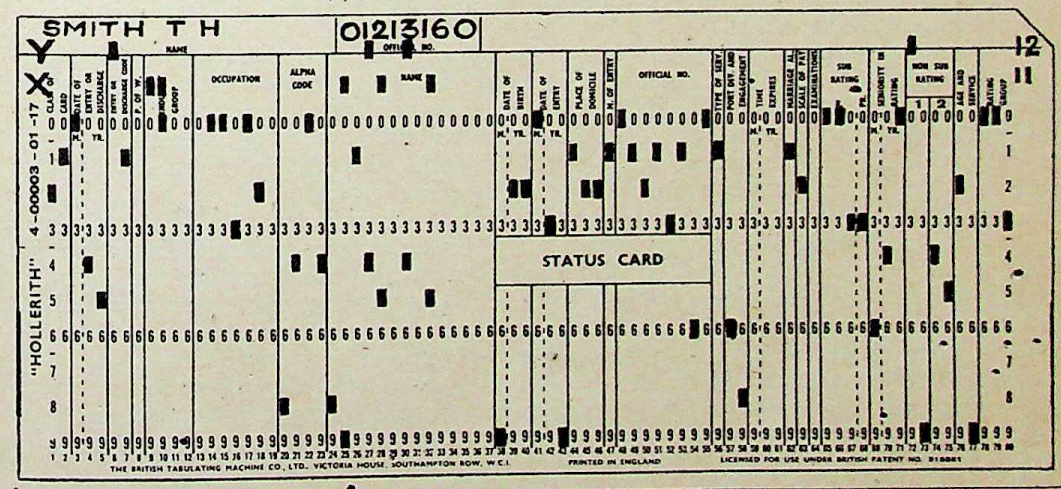
SHIP RENDERING THIS RETURN, DATE, AND OFFICER'S INITIALS.*
NELSON
24th October 1945
Date Stamp may be used.

HOME ADDRESS (1 to 3 only)	DATE OF (1 to 3 only) DISPERSAL	RELEASE
42, George St. Bolton, Lancs.	24/10/45	19/12/45

*Fill up all the spaces outside the *thick* black line. Inside, tick in *one box only*, and add particulars as required.

TO BE DESPATCHED TO Naval Personnel Branch (Statistical Section) Admiralty, London, S.W.1.

(*b*) Punched Card—Release in Class A.



Columns	Description	Code	Decode or Remarks
1–2	Class of Card	21	Maintenance Index Card
3–5	Date of Discharge (Month and Year)	045	October, 1945
6–7	Discharge Code	Y 1	Release in Class A in U.K.
8–80	Details as Fig. 2	—	—

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the punched card from the maintenance file is "pulled" and punched for the date and type of discharge in the (blank) fields which are assigned to date and type of entry or discharge. Statistics of releases are required at half-monthly intervals, and so after the fifteenth and last days of every month all "discharge" cards are sorted and counted to provide the required tables distinguishing Class A, Class B, compassionate releases and other discharges, and also showing "at home" and "abroad," and men and women, separately. These tables also provide the "offs" of the strength statement, analysed by type of outflow. The discharge cards are then reproduced so that the statistics files can have the material for the bulk mechanical extraction of their dead cards, a process which is handled monthly along with the insertion of the new entry cards. They are then stored.

Other tables are required concurrently with those already mentioned, to show the Class B releases and refusals analysed by age and service group, and by industry group and occupational classification number, and also to record the volunteers for retention, and the married W.R.N.S. forgoing marriage priority, in age and service groups. It should be noted, however, that information other than that relating to discharge does not lead to the card becoming "dead," and can be obtained from the S.161R without "pulling" the card except where, as in the case of the W.R.N.S., information on the punched card has to be amended (a new age and service group number); in such cases the cards are kept separate, and after analysis for statistical purposes, are dealt with as shown in the following paragraph for all types of "change." Other forms of discharge, e.g. death, compassionate releases, medical discharges, etc., are notified on a different form (S.161), but the procedure followed is the same.

Amendments to the live index other than those just mentioned are notified on Form S.161, except that changes in marriage allowance used to have a special form to themselves. The process of amendment is illustrated in Fig. 4. On receipt of the appropriate form the punched card is "pulled" from the maintenance file, and the change card illustrated is then prepared. The new card, which may be described as a transitional card, fulfils the double function of automatically producing a new card with the up-to-date information on it, and of furnishing statistics of the changes. For this purpose it has an "old status" side and a "new status" side. The information which is mechanically reproduced on the left-hand side from the maintenance card is selected information; it must, in addition to identifying particulars, such as official number, contain the old particulars in the fields affected by the change, but it is also convenient for it to have particulars which, although not changing, are associated with the changing items in statistical tables currently produced. For example, the illustration shows an advancement from Able Seaman to Leading Seaman, and thus a transfer from Rating Group 3 to Rating Group 2. But as we require to show this as an amendment to the Rating Group-Age and Service Group table in the line of age and service group 29 by a columnar change, it is necessary to have the age and service group punched on the old status side.

The next stage is to "mark up" on the "old status" side the codes for the up-to-date information which must be hand-punched on the "new status" side. This includes the type and date of change. Punching then takes place, after which the maintenance and change cards are merged, in pairs, into one pack. Passing through a selective reproducer gives us mechanically a new maintenance card, from which cards for the "statistics" files are mechanically reproduced; these latter are held for the monthly replacement of the old cards, which takes place along with the insertion of the new entry cards and the removal of the discharge cards. The new maintenance card, on the other hand, is filed away at once. The change card is now free for statistical use, and all such cards are at intervals sorted and counted to provide the information required. Just as strength statements can be kept up-to-date by means of "ons" and "offs," with an occasional direct count at longer intervals for checking purposes, so can, for example, a rating group and age and service group count by use of "change" cards in association with "new entry" and "discharge" cards. When done with the change cards are stored. The selective reproducer operates with a single plug-board set-up for all changes except change of name of a W.R.N.S. rating on marriage, for which a different plug-board is required. If there is a concurrent change in a W.R.N.S. card as well as change of name, two runs through the machine are necessary.

In all, therefore, we have, in addition to the live maintenance file, (1) two live "statistics" files which are brought up-to-date monthly, the process being carried through at different times for the two files in order that there will always be one file in "action," and also to quicken the process

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FIG. 4

Change Card—R.N. Rating. (*a*) Report on Form S.161—Advancement in Substantive Rating.

S.—161 (Revised—October, 1943)	SURNAME.*	CHRISTIAN NAMES (as recorded in Ledger).*	
	SMITH	Thomas H.	F 016401

RATING, ENGAGEMENT, ETC., AS CASE MAY BE, CHANGED TO

NEW SUBSTANTIVE RATING (acting or confirmed) AND PROGRESSIVE RATE.	Ldg. Seaman
NEW NON-SUBSTANTIVE RATING (or "Tr" for Ordinary Seamen.) (or Service Trade, Watch-keeping, & Charge Certificates of E.R.A.'s), etc. (See paragraph 4 of Instructions on cover.)	
NEW ENGAGEMENT (with date of expiry or of completing time for pension.)	
NEW PORT DIVISION OR R.M. DIVISION NEW OFFICIAL OR REGISTER NO.	
NEW BRANCH OF SERVICE (R.N., R.M., etc.) RECOVERED FROM DESERTION. REVERTED FROM DOMINION NAVY. REJOINED AFTER TEMPORARY RELEASE OR EXEMPTION.	
PROMOTED TO OFFICER; DISCHARGED DEAD. "RUN," DISCHARGED TO SHORE (*state cause*) OR RELEASED. (See pars. 1 and 8 of Instructions on Cover.)	
PUNISHMENTS, OFFENCES, OR DISCRETIONARY CHARACTER AWARDS. (See par. 9 of Instructions on Cover.)	

SUBSTANTIVE RATING AND PROG. RATE.*	NON-SUB. RATING.*
A.B.	A.A.3. Diver 2nd cl.

Fill in always. If changed give old ratings here.

PORT DIVISION & OFFICIAL NUMBER.*
C/JX 213160

LIST AND NUMBER ON SHIP'S BOOKS.*	NAME OF TENDER.*
52/429	—

DATE FROM WHICH CHANGE* REPORTED HEREON TAKES EFFECT.
14th September 1945

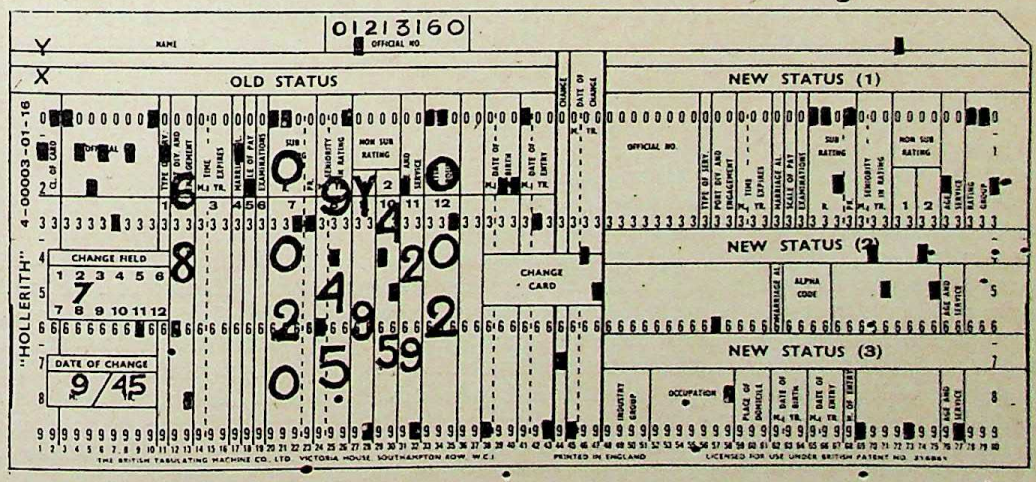
SHIP, RENDERING THIS RETURN, DATE, AND OFFICER'S INITIALS.*
NELSON
15th September 1945.

Date Stamp may be used.

* Fill up all the spaces outside the *thick* black line. The remaining spaces only as necessary

TO BE DESPATCHED TO Naval Branch (Statistical Section) Admiralty London, S W 1
(See K.R and A I Article 1730 b)

(*b*) Change Card—Advancement in Substantive Rating.



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by using all available machines on a single file; (2) a "dead" file in three parts consisting of (*a*) new entry cards, (*b*) discharge cards, and (*c*) change cards. The process of amending a statistics file is a single comprehensive one. The file has been supplied with cards for new entrants, with new cards to take the place of old, and with duplicate discharge cards from the maintenance file. These are all sorted into the order in which the statistics file is kept, forming a batch which is fed into a Collator while the index itself is run through. The new entrant cards will drop into place, the cards for the discharges will match with the "maintenance" discharge cards and drop out, and the other cards will match and change places. In the end all the surplus material goes for "pulping."

Resulting Statistics—General Observations

The statistical tables, analysing releases and residual strength, which are produced as a result of the operations described in the previous section, need not be further particularized since they have already been mentioned. By way of conclusion, however, some general remarks are offered. The work entailed in demobilization, and for which the statistics provided by the machine are used, begins with forecasts and ends up with facts. When requirements in manpower at any given date are determined, and when with an eye to a still later date the allocation of new intake for the current period has been fixed, it is possible to estimate on the basis of past experience the amount of the ordinary wastage, and so determine the amount of demobilization releases that can take place. Class B being of the order of 10 per cent. of Class A, the number to be released in Class A is calculated, and this enables an estimate to be made of the average age and service group to be reached on certain assumptions as to the proportion volunteering to continue serving. A programme can then be worked out for some way ahead, to be revised in the light of circumstances. It is obviously much easier to fix the numbers to be released than to determine the last group to be reached, but yet it is the group which interests both the Service and the general public. As time passes the statistics of the actual releases show performance in meeting the programme. There is a very simple linear equation that is continually recurring in this work—so simple, in fact, that it is not necessary to express it in algebraic terms. It is to the effect that the strength at the end of a period of time is equal to the strength at the beginning of the period, plus the intake and minus the outflow during the period. But, like all equations, it must be remembered that both sides are equal, and not only does this apply to the checks imposed as the work proceeds, as for example, when an occasional direct count of residual strength is made in order to check the operation of the monthly "on" and "off" system, but we must also endeavour to solve the equation up to the target date which has been the basis of the estimate of releases made, especially when these latter have been widely publicized. If requirements are in fact reduced to the calculated figures, and if intake and ordinary wastage conform to estimates, then the demobilization targets will be attained. But there are anxious moments during the process. From June 18 to October 15, 1945, one-third of the total planned releases of male officers and ratings scheduled to take place by December 31 had been reported, and the question was whether the remaining two-thirds would be achieved in two-and-a-half months. It seemed best to consider the outflow under three heads: (*a*) all releases, i.e. Class A and ordinary wastage, within the Age and Service Groups ordered for release by that date, because the content of these Groups was known at the beginning of the period, and the voluntary retentions were reported (the small number of Class B releases between Groups 22 and 31 (average) also came in, but was not a large factor); (*b*) the Class B releases, the programme for which was fixed in advance, and a generous surplus of names promulgated in the attempt to counter a possible short-fall, in view of the voluntary nature of release under this head; and (*c*) other releases and discharges from groups beyond those to be reached by December 31 for Class A release.

Now in view of the fact that on June 18, 1945, plans were in operation for what might have proved a protracted war against Japan, the target then set for releases by December 31 of that year was only a fraction of the one ultimately put into operation. Two fresh targets were, in fact, set, each considerably larger than the one before. Releases were therefore expected to proceed at an accelerating rate, and the releases reported during a past period of short dimensions were no guide to the final figures. It was found, moreover, that it took a long time for reports to reach the Admiralty from the many dispersal centres, despite all that could be done to accelerate the process, and allowance had to be made for this time-lag. It was easy, by sorting, to allocate

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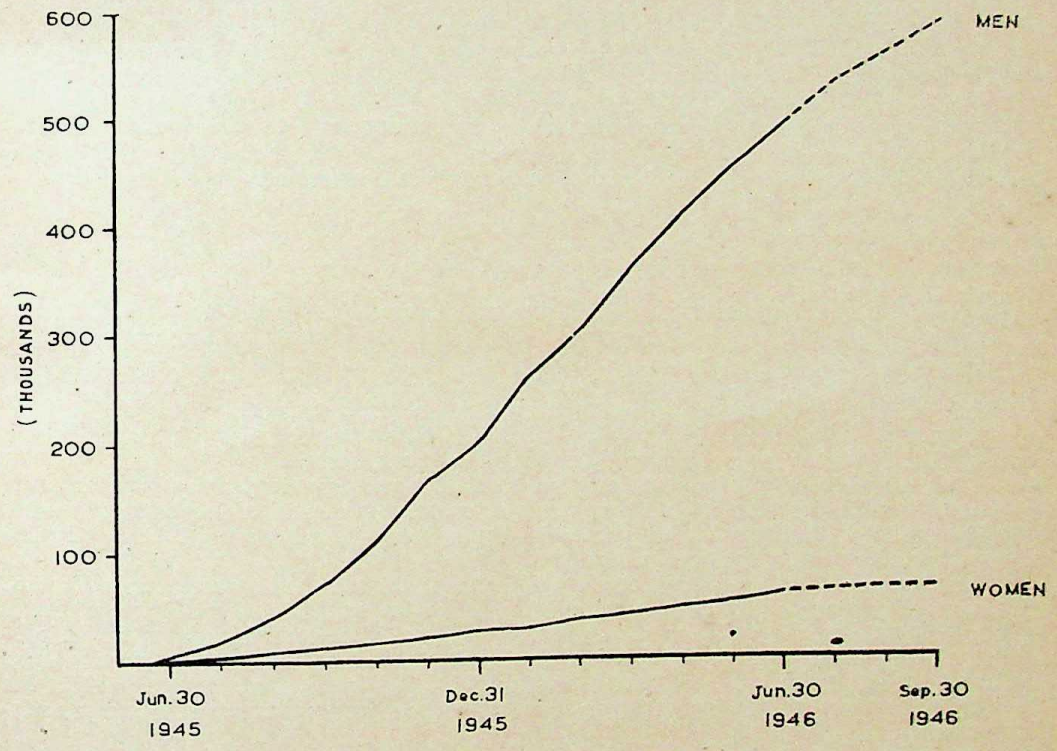
the releases reported by, say, the end of December to the half-month of their occurrence, and thus it was possible in time to record revised figures of the releases effected by certain dates. The trend of these figures, in relation to the programme, then enabled an estimate to be made of the number of reports outstanding, so that at the end of December, for example, the report which was called for contained, in addition to the numbers reported to the Admiralty as having been released, a further number which was the estimate of the releases made, but for whom reports had not at that date been received. These estimates proved later to have been quite accurate; in all cases, by the time three months had elapsed it was found that the releases were just a little higher than estimated, but this was not surprising, since the calculations were made on a conservative basis in order that we should not be claiming more than the actual performance.

FIG. 5

Total Numbers Released (in thousands) to 30th September, 1946



The anxious moments passed, and it was with a considerable measure of relief, and satisfaction, that soon after December 31 a report was furnished showing that the target for men of 199,000 total releases was estimated to have been passed by some 3,500. Women caused no anxiety, owing to the linear rate of release planned and executed by the Director, W.R.N.S., and they well exceeded the numbers asked for. By this time we were well set, and it was then a case of keeping up approximately the same rate of release as had been achieved by the end of 1945 for the following six months. After that period the rate fell slightly in accordance with agreed plans fixing the strength of the R.N. at the end of 1946. A graph of the total releases actually effected at monthly intervals is shown in Fig. 5 for men and women separately down to September 30, 1946. The graph is shown dotted between June 30 and September 30, since for that period estimates are incorporated of the releases not yet reported. The figures are given in Table 5.

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TABLE 5.—*Total Releases* (*Cumulative Figures from* 18.vi.45)

	Men.	Women.
31.vii.45	20,732	4,551
31.viii.45	41,559	9,294
30.ix.45	72,776	13,584
31.x.45	110,561	18,796
30.xi.45	166,290	23,267
31.xii.45	203,193	27,930
31.i.46	261,295	31,144
28.ii.46	305,227	37,377
31.iii.46	367,022	42,127
30.iv.46	415,677	48,032
31.v.46	459,382	54,452
30.vi.46	497,807	59,786
31.vii.46	536,200* (1,100)	63,022* (50)
31.viii.46	560,589* (3,700)	64,831* (100)
30.ix.46	589,863* (14,000)	66,201* (500)

* Estimated figures (the estimated addition to actual reports being shown in brackets).

Acknowledgment is made to the Board of Admiralty for permission to read this paper.

DISCUSSION ON DR. WISHART'S PAPER

MR. R. F. GEORGE: It gives me very much pleasure to propose a vote of thanks to Dr. Wishart for the paper we have listened to this evening. I feel that with this account of how demobilization in the Royal Navy has taken place, as a piece of statistical planning, those Fellows—and there are doubtless many of them—who a year ago were smarting under a sense of injustice, probably feel a little more relieved now they understand something of the complicated nature of the affair. They will not, of course, feel entirely satisfied, but I think that is probably due to a reason beyond the control of the statistician, a point to which I shall refer in a moment.

It is quite clear that Dr. Wishart encountered several difficulties in preparing this paper, and I feel that not the least of them was obtaining permission from the Board of Admiralty to read it. I shudder on Dr. Wishart's behalf when I think of what would have happened if he had applied for permission, say, a year or fifteen months ago.

One of the special merits of the paper is that it brings home to us an elementary point that statisticians are too apt to forget, that whatever the analysis we may apply to the figures, whatever the calculations we do, after all is said and done it is the nature of the organization and the administration behind the material that determines its validity. It is no use merely accepting large numbers because they are large, without considering how they were produced; Dr. Wishart has lifted the curtain, and we are able to assess the merits and demerits of demobilization as a statistical exercise.

It is a year or more since Service and public indignation was expressed at the rate of release. I think a paper on these lines at that time would have done a good deal to pacify public resentment, but not all, because we must not forget that in the question of demobilization the rate of release is basically determined by a fact far beyond the power of the statistician to influence. The rate of release is essentially determined by decisions taken on the part of the Chiefs of Staff concerning the numbers below which the Service population must not be allowed to fall. That decision is presented to the statistician as an immutable fact, and against that decision he has got to frame his machinery and devise various measures to make it effective. That point was not entirely overlooked a year ago by the more responsible of the critics.

We have listened this evening to an explanation of the complicated way in which the statistical machine behind demobilization had to be devised and had to work. That necessarily follows from the complex character of the modern force. Specialization, during the six years, was practised to a degree we have never witnessed before, and the Service population, not only in the Navy but in all three Services, consisted of a large number of branches of duty for officers and trades for men, to be fitted together in their appropiate proportions like a jigsaw puzzle.

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The problem in the first few years of the War was to build up that picture, fitting together the trades in their proper proportions, allowing trade by trade, branch of duty by branch of duty for the varying lengths of training—and the training course is not inflexible; it can be shortened or expanded to accelerate or delay the flow of population in the desired channel. We have also to allow for varying degrees of wastage according to the trade and branch of duty, before and after the training is completed.

In the closing months of the War the converse applied. The problem then was how to diminish the picture, and this problem is not precisely the same as the earlier one. To reduce this jigsaw puzzle we have to bear in mind the appropriate proportions between the trades and branches of duty, and between the officers on the one hand and the ratings on the other, and the fact that those varying proportions are not the same in a diminishing force as they are in an expanding force. I emphasize this point because I feel it bears upon one feature of the paper that is particularly worth noting. On p. 33 Dr. Wishart indicates that release in terms of age and service groups was not the same for all men, and consequently it had to be expressed in terms of the overall average. This surely is an outstanding example of the misleading character of the average. It is not the overall average that matters nearly so much as the detailed build-up within that average. We want to get behind the average group release and find what is happening in the detail. Would it not have been more satisfactory, for example, in the circumstances, to have indicated the *range* of the age and service groups expected to be released, rather than one age and service group which embraces several that might lie on either side—probably more behind than in front, but that we do not know? The overall average could not possibly have applied to a very large number of men who watched these announcements with a keen sense of personal interest, and I think it is this feature of the demobilization process which is obscure in Dr. Wishart's paper. In this respect he encourages us to ask for more information.

He says in his concluding paragraph that early in 1946, despite fears and apprehensions, the rate of release was in fact in advance of the programme by a small amount—$1\frac{3}{4}$ per cent. But that, as I have emphasized, is just the overall picture; what about the range within the framework? Even if the final result were absolutely perfect, there is still plenty of room for variations and compensating errors, and I think it is small comfort for the man whose release has been delayed to be told that there are, on the other hand, many whose release has been accelerated. It would be illuminating to see the figures for the main trades, trade by trade, of expected release group numbers against the achieved group numbers, at a few selected points of time. A proper appreciation of the problem is by no means simple, and it does involve a highly complicated statistical technique. Having read Dr. Wishart's paper I thought, "Heaven help the officer who, allergic to figures, finds himself in the Administrative Branch, deeply engaged in this work."

With regard to Class B releases, Dr. Wishart gives some figures showing what a large proportion of refusals there are in those early age-groups, where he divides the Groups at 31. What more can one expect? To accept release under the Class B scheme a man forfeits certain advantages and incurs certain disabilities in his civilian life. Is it worth while to jump one or two numbers with that prospect in view? I think if the Class B release had, generally speaking, been offered to a much higher group number than, apparently, it was, we should have had far fewer refusals, and actual achievements could have been much more accurately forecast.

A satisfactory response for the Class B releases could only have been achieved by offering such release to men in Age and Service Groups well beyond those qualifying in the near future for normal release.

Dr. Wishart will, I am sure, take these observations as evidence of the interest that his paper has aroused, and I should like to finish where I began, by proposing a most cordial vote of thanks to him.

MAJOR PADLEY: In the year 1835 there appeared in the *United Services Journal*, under the authorship of a young Indian Army Officer, Captain A. N. Tulloch, two articles on the calculation of the value of military pensions. So far as I know, these articles represent the first published papers which inaugurated a new subject of military demography—a subject to which Dr. Wishart's lucid paper this evening is a very distinguished as well as the latest contribution.

It is quite impossible in keeping records of military personnel to distinguish an exact point at which calling the roll ends and the compilation of statistics begins. In a sense I imagine Homer's "Catalogue of Ships" could claim authority as one of the earliest Naval statistical documents. It is, however, a wholly modern phenomenon for personnel statistics to be kept centrally, and on so large a scale. Gibbon estimates the whole military forces of Rome—legions, navy, auxiliaries, allied cavalry, camp followers—at about 450,000 men. As Dr. Wishart has shown, the Navy alone has demobilized a larger number than that, and handled them in a little over a year. In the Army an even larger number has, of course, been dealt with.

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In keeping records centrally and in applying to them the techniques with which the Fellows of this Society are familiar, I think the Medical Services of the British Army can claim to have been pioneers. Shortly after the publication of the articles by Tulloch, which I have mentioned, the then Secretary of War, Grey, who was concerned over the cost of replacing soldiers invalided back from the Colonies, brought Tulloch into the War Office in order to prepare a series of reports on rates of sickness, invaliding, and mortality in the British Army. The first of these was published in 1837, in the same year that the Registrar-General's Office was founded, and was summarized in the following year in the first volume of the *Journal* of this Society. The close connection which this Society has had with military demography did not end with that first volume of the *Journal*, for Tulloch's successor, a certain Major-General Balfour, was President of the Society in the years 1888 and 1889.

Indeed, during the nineteenth century as a whole demographic statistics of a military nature were regarded as of general importance, and the point was conceded that it was from the study of how to record personnel statistics in the closed populations which military forces offered that lessons might be learned for civilian application.

With regard to sickness statistics, Dr. William Farr stated categorically in the thirty-fifth annual report of the Registrar-General that the ultimate aim was a return of the cases of civilian sickness as complete as that then provided by the Army in England.

If, so far, in expressing my thanks to Dr. Wishart for his paper, I have spoken about the medical side of military personnel statistics, it is because they are the best recorded historically, and because I believe that it was the efforts of the nineteenth century medical statisticians in the Army which paved the way for the complex systems of personnel record-keeping such as Dr. Wishart has described.

Since the recent War the Army, as well as the Navy, has, of course, had a certain amount of man-power to reallocate, and the Adjutant-General's department, faced with a similar problem to that of the Navy, met it in a similar way. The War Office Central Card Index, which achieved almost a notoriety in the Press at one time, coped both with the demobilization problem and also with the earlier problem of allocating, in accordance with a complex scheme of personnel selection, man-power drawn in from civilian sources with, *mutatis mutandis*, the use of a similar Hollerith-based system to that which has been described this evening.

But I think Dr. Wishart and the Council of the Society, in choosing this paper, should receive our thanks on another ground. In recent times statistics have been compiled against a background of fairly small-scale enterprise and by comparatively poor University Departments or Research Departments, and they have concentrated very much, as we all know, on sampling processes. In dealing with the statistics of personnel, sampling is inevitably a *pis aller*, as compared with total enumeration. The compilation of total enumeration statistics sets up its own problems, as we have been shown this evening, and those problems have had far less public airing. There are far fewer papers describing large-scale enterprise of such a kind, and when such a paper does appear it is, in consequence, the more welcome. It is, therefore, with very great pleasure and at the same time, I hope, with the befitting deference of the junior towards the senior Service, that I second the vote of thanks to Dr. Wishart for his paper.

The vote of thanks was then put to the meeting and carried unanimously.

Admiral DENNY said that as the officer who bore any blame to be given to the statistical body which Dr. Wishart had described, he heartily agreed with everything the speaker had said, but he thought he had missed out one or two of the more practical points regarded by the more common or garden Naval officer. The problem was a double one. They started off with a ceiling strength when demobilization began, and they had to end up with a ceiling—or rather a ground floor—when it was over. The ground floor was being built up continually by the new entrants, and the ceiling continually lowered by the normal wastage and the process of demobilization.

It was a fact that the statistical control exercised made it easy to be certain of the build-up of the floor, and equally certain of the rate at which the ceiling lowered itself, by an accurate recording of the releases and normal wastages, but the final state of affairs when the ceiling came to rest and met the floor depended essentially on what was the ceiling when they first started, and he was sure the Army and the Air Force had met with the same trouble. To be quite frank about it, they did not know how many men they had. As statisticians they would appreciate that if there was an error of x at the beginning of the operation the process would inevitably result in the same numerical x error being present at the end. Now 10,000 wrong out of the best part of 800,000 men was not very much expressed as a percentage, but 10,000 when it related to, say, 175,000 men was a very different matter.

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The people interested in what happened in the end were, of course, the general public. The strength of the forces was not determined quite as the proposer and seconder of the vote of thanks had indicated, namely by the Chiefs of Staff. It was true they did deliberate and put forward proposed strengths, but those strengths might be quite a different figure from what they were asked to achieve, and the Government, after taking into account all its other responsibilities, might in fact determine a totally different figure, and they had to produce forces of that dictated strength at a given date.

The demobilization scheme was called the reallocation of man-power; the term "demobilization," as Dr. Wishart had pointed out, was avoided. The Minister of Labour was the man principally concerned in what happened about that reallocation of man-power, and he was concerned principally in the number of people demobilized, on the assumption that every man demobilized went and did something else in the National economy. So the Services had to produce and act up to two separate things which only met together in the statistical analyses—one, a final strength figure at a given date, and two, the release target figure. They might satisfy one, they might satisfy both, but it was a fact that if any Service succeeded in hitting its target strength figure and its releases figure on December 31st of that year, it would be a miracle, and would therefore result not entirely from correct statistical control, but from a judicious mixture of statistical control and ingenious crystal-gazing.

One was asked to produce a release figure six months in advance, and as Mr. George had pointed out, the more information they could give to the troops the better, but anybody who attempted, in the case of the Navy, for example, to define to every single rating category where any given category would stand in six months' time would be asking for a 200 per cent. increase in Parliamentary correspondence over the present 200 per cent. increase which had occurred since this started.

Distribution of the Class B releases amongst Age and Service Groups was a very good example of this. It was impossible to predict where those people who came out in Class B would occur in the distribution table. The same thing happened every time the target strength was altered—and it had been altered six times—their predictions of where it was going to stand naturally had to be altered, and it led them into frightful difficulties. For example, the biggest rating category in the Navy was the Seaman Branch which Dr. Wishart had mentioned. On their original target strengths they would have had time to enter sufficient men to present the fast release programme being completed before the necessary replacements were made, but the release programme was accelerated and they were given six months' less time to replace them, and were now stuck at a pocket in their Seaman table containing an immense number of men whom they could not possibly send out in one month or even two. That was the explanation why he had had over 200 complaints in two months of "Why were the Seamen marking time?" It was extremely difficult to control that sort of thing, and to effect the simultaneous achievement of the two requirements: namely an exact adherence to the release programme and an exact hit on the target strength at any given date.

He hoped that somebody would read a paper to the Society one day on Operational Research, which, as Dr. Wishart well knew, was the other branch in the Navy which had contributed so much to their job; that was to say the study of operations by statisticians to evolve a method of conducting operations with greater efficiency. In exactly the same way as Dr. Wishart had studied the demobilization problem from the statistical point of view, so the subject of conducting operations was studied from the statistical point of view to find out the best way of conducting them. In its scope it was the biggest survey the Navy had ever conducted, to which, no doubt, many members of the Society had contributed.

Mr. SEAL wished to join with the other speakers in thanking Dr. Wishart for his paper. He hoped that this paper from the pen of a well-known mathematical statistician would help to convince those who were inclined to despise statistical problems not requiring abstruse mathematics for their solution, that often enough in the apparently simpler problems there were hidden depths of difficulty which only the higher-trained statistical mind could grapple with effectively.

An immediate instance of that was the problem of how many files of identical Hollerith cards to maintain. He presumed a theorist would say it was very simple: you kept as many files in different prescribed orders as there were types of recurring questions to which these files would facilitate the answer. In order to effect day-to-day changes in the files one file would be a "working file," and the collator would automatically ensure that the remaining files were adjusted in the same manner. However, he wondered if anyone who had kept as few as three files of Hollerith cards had succeeded in keeping them "identical" for any period, and he thought it was a very serious problem for the statistician to decide—should one have one file of Hollerith cards and keep sorting it and re-sorting it, or should one try to keep n files of cards, where $n>1$, and

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have relatively little sorting to do in answer to routine enquiries, but never be quite sure that the *n* files were precisely the same? It was a problem that needed careful consideration in each individual case.

The second point he wished to bring up concerned the future of the statistical organization that Dr. Wishart had mentioned in his paper. Probably people felt that as the Navy gradually worked down to its peacetime level, statistical problems of the type outlined by Dr. Wishart would disappear; that the problem of building up the Navy rapidly and following it statistically was a wartime job, whilst the problem of demobilization was an immediate post-war one. It would thus appear that in peace there was no statistical problem there at all. He believed, on the contrary, that peacetime planning was really the more interesting and just as important. The planning of a proper career for a Naval rating or officer, the securing of an age distribution which would enable the "right" number of deaths and retirements (whether for "age" or "ill-health" reasons) to be attained, was, he suggested, a statistical, mathematical, and demographic problem of the highest type and with the most serious consequences for all of them, whether as statisticians or administrators.

Mr. R. B. AINSWORTH sent the following written contribution, which was read by Dr. C. Oswald George: Dr. Wishart's paper lifts one corner of the curtain which has concealed the details of the statistical work which has provided the basis for planning and carrying out demobilization The success of the operation, as in the case of the mobilization of man-power for the Services and for industry, was very largely due to unspectacular statistical work in various Government Departments. This work, as he says, was not of an interesting mathematical or theoretical statistical nature. It consisted of planning and directing large blocks of clerical and mechanical work, coupled with the exercise of a considerable degree of foresight into the nature of the statistics which would be required.

The problems involved in the demobilization of the Royal Navy were, as shown in the paper, many and intricate. They were, however, successfully dealt with, and in confirmation of this I would like to add two figures to those of releases up to September 30th given in Table 5. The programme figures for this date were 600,000 men and 67,800 women. The numbers of actual releases therefore (589,863 and 66,201) came reasonably close to the target. It is perhaps of interest that the same compliance with the programme attended the release of men and women from the Army and the Royal Air Force. The Army released 2,441,670 against a programme of 2,428,400, and the R.A.F. 890,680 against 885,440.

On the question of the numbers released, Dr. Wishart refers to the fact that it was the intention that Class B releases should be of the order of 10 per cent. of Class A. The releases up to September 30th from the Navy, however, showed a proportion of only 3·7 per cent. The corresponding figures for the Army and the R.A.F. were 10·1 and 8·1. The explanation probably lies in the fact that the majority of the Class B releases were of men in the building and civil engineering industries and in coalmining, and that the proportion of such men was smaller in the Navy than in the other Services.

So far as demobilization was linked up with the post-war manning of particular industries, the value of the system described by Dr. Wishart was that it enabled the men for release in Class B to be readily identified. The release of men and women in this class for essential industries and services has played a very important part in the readjustment of man-power. The original programme of October 2, 1945, provided for the release in this class of 147,580 from all the Services. On January 25, 1946, a revised programme was announced providing for the release of 300,182. This figure covered a wide range of industries, from the building and civil engineering industries with 120,000 to steel sheets, deep-sea fishing and fertilizers with 500 men in each, and flax and jute with 250 women in each. The selection of the quota to be provided by the Navy and by the other Services for each occupation, complicated by the necessity for maintaining the necessary strength of the various ratings, and by the refusal of considerable numbers to accept release, was obviously only possible on the basis of a system such as that described in the paper, which it should be noted had been devised before it was known what problems would arise. There was one flaw in the system, however, which was perhaps inevitable. The classification of men in the Forces according to particular industries and occupations was based on their occupation at the date of registration, and it did not take into account any training before calling-up or while in the Forces. Thus, many who were classified as students were in fact trained for various jobs prior to demobilization. Records were no doubt kept of Service training and used in connection with the maintenance of the strength of various ratings, but they do not appear to have been used for selecting persons for release under Class B. So far as Class A men were concerned, no important use could be made of the industrial and occupational classification in connection with the post-war statistics of industrial man-power. These men were free to enter any industry, and the record cards showing

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their occupation at the time of registration were of no value in determining the numbers who went into the various industries on release from the Forces.

Dr. WISHART, in reply: My first reaction to the discussion is one of gratification for the kindly reception given to the paper. When I consider that my previous papers, given to this and other Societies, have been of a very different character, and that I cannot claim ever to have had any formal training as an official or descriptive statistician, it is satisfactory to note that Mr. George and Mr. Seal have not had any serious criticisms to offer, and that, as stated by Major Padley, I have apparently succeeded in making a contribution to military demography.

Mr. George, as befits a man who can speak with authority on service personnel problems, including the demobilization aspects, from his long connection with the Air Ministry, makes a pertinent point on the "public relations" side of the work, and another on the Class B scheme. On the first, the overall average was not so much misleading as insufficient. The numbers to be released were, in fact, made up in the office by considering the rating groups one by one. While the first public statements, like other purely general statements, gave only the average group number to be reached by a given date, adding a few details about the rating groups which would lag behind the rest, Admiralty General Messages were later issued in which the full programme was given, and these were released to the press. Statistics of the actual releases, broken down into age and service groups and rating groups, for comparison with the planned programme, have not been given in the paper, but they were available in the Admiralty at all material times, and followed the course to be expected from the orders issued.

On the second point, Mr. George suggests that a better response to Class B releases would have been achieved by going well beyond the Age and Service groups qualifying for normal release. This may well have been so, particularly at the outset. The 3·7 per cent. mentioned by Mr. Ainsworth was a constant disappointment, and the intractable nature of the problem, despite a generous dipping down that was undertaken as soon as it was seen that the target was not being met, suggests that Mr. Ainsworth's explanation is probably the right one. There were more than enough men in the Navy to provide the necessary quotas, but the factor of refusals had to be taken into account. The Army and Air Force may well have had a much greater surplus.

Admiral Denny's mention of the uncertainty attending the numbers in the Navy should be taken with Mr. Seal's plea for the recognition of the importance of statistics in personnel divisions in peace-time. Statistics were to some extent neglected between the wars, and did not get the necessary priority when war broke out to lay the foundations of a really efficient organization for the handling of the many problems that arose, the latest of which is dealt with in this paper. This is one of the lessons which the war has taught us, and we seem to have profited from the experience, as judged from the establishment of a statistician class in the Civil Service, and the organization of branches like the present Statistical Branch of the Admiralty. It is to be hoped that this branch will not suffer the fate of the corresponding organization which survived the first world war, only to fall at a later date. I agree with Mr. Seal that, in addition to knowing how many men there are in the Navy, there are many problems of peace-time planning which can be tackled statistically, not the least interesting of which is the career problem, an interesting admixture of statistics and actuarial mathematics.

Mr. Ainsworth compared the releases with the programme figures for all three Services, and for September 30th showed that the Navy was behind its target by a small amount, while the other Services were not. It is fair to add that this was the first month in which such a deficiency was shown, and it was due to a necessary revision of plans. A similar comparison at monthly or quarterly intervals since releases began would show the Navy in a very favourable light.

The flaw in the Class B scheme alluded to by Mr. Ainsworth was one for which the Service Departments cannot accept responsibility. They were not asked to release men in Class B who had been trained during their service career in the desired occupations. Command Paper 6548 envisaged the release of men in Class B "on account of their qualifications for urgent reconstruction work." This was general enough, but the scheme was administered, possibly somewhat rigidly, by the Ministry of Labour along the lines described in the paper. So far as the Navy was concerned, men were given the opportunity to make representations if they considered that they were in the class covered by the names sent out to the Fleet. It is disappointing to learn that for Class A no important use could be made of the pre-entry occupation statistics of the men released, particularly as one of the biggest single tasks that had to be performed was to array the entire "War-only" Navy by occupations and age and service groups, at the behest of the Ministry of Labour. It is true that the men were free to enter any industry, but I should have thought the information would be useful for statistical purposes, as in framing man-power

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budgets of the numbers required in the various industries in the reconstruction period. The problem was, of course, complicated by the release of large numbers from the munitions industries, but it would be interesting to know whether a comparison was ever carried out between the man-power estimates made before demobilization and the actual numbers who have settled down to civil life in the various groups of industries.

May I conclude by expressing my appreciation of the very kind remarks that have been made on the paper by the mover and seconder of the vote of thanks, and by the other speakers?

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Albert Edward Owen Churches, B.Com.
Walter Cullen, Capt., E.M.E., A.M.I.I.A., A.M.I.E.S.
W. Manning Dacey.
George Edney, B.Com.
Olaf Leonard Erik Ellefsen.
Mary Elsworth Greaves.
Henry Albert Hake, A.C.I.S.
Eric L. Huppert, Ph.D.
Ella Knight, M.A.
Horace William McLellan.
John Rowland Manning.
Francis John Monkhouse.
Charles William Pache Orr, LL.B.
Alexander Thomson Park, M.A.
Hugh Cyril Stanton.
Francis Herbert Thomas, M.B.E.
Terence Edward Haydn Thomas, B.Com.

Corporate Representative

Rolf Peter Lynton, B.Sc., *representing* Leathley Publications.

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MISCELLANEA

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Report on the Teaching of Statistics in Universities and University Colleges.

I. Introduction.

1. In view of the growing recognition of the importance of statistics in government, in commerce and industry and in scientific research, the Council of the Royal Statistical Society decided in 1944 that the time was opportune for a survey of the whole question of the teaching of statistics. A committee was appointed with the following membership: Professor E. S. Pearson (Chairman), Professor R .G. D. Allen, Mr. H. Campion, Sir William Elderton, Dr. C. Oswald George, Mr. R. F. George, Professor M. Greenwood, Dr. D. Heron, Dr. J. O. Irwin, Mr. H. Leak, Dr. E. C. Rhodes, Mr. R. Stone, Mr. L. H. C. Tippett, Dr. J. Wishart. The Council have now considered the Committee's report on the teaching of statistics in the universities and submit their views in the following memorandum.

2. As part of their investigation, the committee forwarded a questionnaire on the present position of the teaching of statistics to universities and university colleges in the United Kingdom and Eire. The information received has played a valuable part in framing this memorandum, and the Council desire to express their thanks to the institutions who have helped by supplying the data.

3. In the remarks which follow, the Council have in mind universities, university colleges and technical colleges of university rank, but will for convenience refer to them all under the term "the universities."

II. The Importance of Statistics.

The Need for Professional Statisticians.

4. Most public discussion on statistics during recent months has brought out the need for the services of qualified statisticians. In their Memorandum on Official Statistics* the Council recommended that the Civil Service should create some specifically statistical posts and recruit staff suitably qualified to fill them; they note with pleasure the recognition of the class of statistician at the administrative level in the Civil Service.

5. More recently the Committee on the Provision for Social and Economic Research under the chairmanship of the late Sir John Clapham have stated in no uncertain terms the importance of, and the unsatisfied need for, statistics:

> "We cannot leave this part of our report without some comment on the quite inadequate provision which at present prevails in universities in the United Kingdom for posts in statistics. An adequate supply of statistical competence is quite fundamental to the advancement of knowledge of social and economic questions. It is no less essential in public administration. Yet the number of chairs in statistics throughout the country could be counted on the fingers of one hand. It is small wonder that, during the war, statisticians were probably the scarcest of scarce commodities, and that, now the war is over, a chronic struggle is going on between the universities, business and the public service for the services of a supply of statisticians which is in the aggregate equal to only a tiny fraction of the demands immediately manifesting themselves, and still less of the demands which are certain to accrue as current policies develop and projected institutions are brought into being. There are few more urgent needs to-day than the increase of the supply of first-class statisticians. But this need will not be met if further provision is not forthcoming at the universities."†

* *Journal of the Royal Statistical Society*, cvi, 1943, p. 145.
† Cmd. 6868, 1946, pp. 8–9.

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6. The advertisement columns of the press also bear witness to the demand by public and private bodies for statisticians to work in a variety of fields. It is known that in a number of cases in the government service, in the universities and in industry, it has been found impossible to fill these posts with persons having the qualifications desired.

The Need for Training in Statistics as Ancillary to Other Subjects.

7. Equally important with the requirement for full-time professional statisticians is the need within the universities for instruction in statistical methods as tools ancillary to other subjects. This point was recently emphasized by the Royal Society in a report on the balanced development of science in the universities of the United Kingdom drawn up in May, 1946, but not yet published, which the Council has had the privilege of seeing.

8. *Social Sciences.*—Statistics is traditionally regarded almost as another term for quantitative economics, and most workers in all the social sciences find themselves from time to time in situations requiring a working knowledge of statistical methods and of what we have elsewhere* termed "descriptive statistics" (e.g. the collection and interpretation of economic statistical data). Most university courses in economic and related subjects include a few lectures in statistics, but they do not all deal with the subject in a way we regard as adequate.

9. *Biology and Medicine.*—A quantitative approach to biology in all its branches, pure and applied, is essentially statistical. Most quantitative laws are statistical in the sense of applying to groups rather than individuals, and a knowledge of the principles of statistical method is a powerful aid in the planning of experiments and the interpretation of their results. We are convinced that the time has come when all biological research workers, including those concerned with agriculture, should receive some training in statistical methods.

10. *Chemistry, Physics and Engineering.*—Statistics has also invaded the so-called exact sciences of chemistry, physics and engineering. Modern theories of matter have a statistical basis, and scientists have to free their minds from the limitation of thinking only in terms of individual things, exact laws, and unique quantities determined with perfect precision; they have to comprehend aggregates, statistical laws, and quantities subject to errors and variations that occur with various probabilities. There is a call at the moment for more teaching of statistical mechanics; it would be a pity if this subject were thought of as something entirely different from statistics in general. Workers in the exact sciences, especially those who go into industry, often find that precise control of experimental conditions is, for one reason or another, impossible, and recourse must necessarily be had to statistical methods. It has often been found that experimentalists, trained only in the "classical" methods of the exact sciences, are baffled in this situation; sometimes when they have turned to statistical methods for aid, they have done so without adequate study and with a *naïveté* that has rendered their work ineffective. The only corrective for this is an adequate training in the fundamentals of statistical methods.

11. In recent years, too, special statistical methods have been developed for the control of quality in production in the chemical and engineering industries. We consider that statistical methods applied to engineering investigation and processes should be developed as a subject for instruction to students in engineering departments; further, that this recommendation should be extended to chemistry and physics. We do not expect that the authorities will insist on all students in these three faculties studying statistical methods to the level we have in mind here, and for the time being would be content with an extension to more universities of the special or post-graduate courses, now given in some universities and available to selected students. We are confident that if this is done, the demand for the courses will grow.

12. The importance of introducing some knowledge of statistics as an ancillary study in the curriculum of students specializing in other scientific fields is derived from the fact that the successful use of statistical technique requires good knowledge of the field of application. The scientist working in any field should not only be his own statistician for everyday purposes, but when he needs to consult the professional statistician he should remain in control, postulating the problem and examining the solution critically. Although it is the duty of the professional statistician to learn enough of the field of application, co-operation will be satisfactory only if

*In our Memorandum on Official Statistics.

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the experimental scientist also appreciates the statistical approach and has learnt something of statistical methods.

THE NEED FOR A MORE WIDESPREAD KNOWLEDGE OF THE STATISTICAL APPROACH.

13. In the previous section statistics has been referred to as a tool to be used as ancillary to other subjects; but if a set of ideas and methods is ancillary to so many scientific subjects, it has clearly a position of fundamental importance. In the social and natural sciences, for every worker who has need to use statistical methods, many have occasion to appreciate results and arguments having a statistical basis. It is strongly urged that all students in these sciences should have some familiarity with statistical ideas and the most common methods, as part of their background knowledge.

14. This point is stressed also because, in the Council's view, the statistical approach is so fundamental to the modern way of looking at things—the affairs of everyday life as well as scientific theories and experiments—that it should form part of the mental equipment of the educated man, which it is not at present. Most people, whether their formal education finishes at school or the university, when they think quantitatively and scientifically, do so in terms of the conceptions of "classical" physics. When they have to adopt a statistical viewpoint, a conscious and often difficult mental reorientation is required.

15. Sir Charles Darwin, in his Presidential Address to the Mathematical and Physical Sciences Section of the British Association in 1938, expressed the hope "that generations will grow up which have a facility that few of us at present possess in thinking about the world in the way which the quantum theory has shown to be the true one. The inaccuracies and uncertainties of the world will be recognized as one of its essential features. Inaccuracy in the world will not be associated with inaccuracy of thought, and the result will be not only a more sensible view about the things of ordinary life, but ultimately, as I hope, a fuller and better understanding of the basis of natural philosophy."

16. We share that hope, and think it may ultimately be realized through the teaching of statistics in schools; but until this is done there is an added responsibility on the universities to supply a lack in the mental equipment of their undergraduates, and to provide the next generation of schoolteachers with the right background. We do not propose at present that universities should attempt to fill this gap in general education, but in so far as they do so for special reasons in the case of all students in the sciences mentioned, they will be contributing to the general dissemination of statistical ideas and methods and to their full assimilation into the educational curriculum.

THE NEED FOR SCHOOLS OF PURE STATISTICAL TEACHING AND RESEARCH.

17. The need for practising statisticians is apparent, whether in the Civil Service, in the professions, in industry, or as university teachers; the importance of giving a training in statistical method to students in all scientific subjects is being increasingly recognized. These requirements carry with them, however, the less apparent but fundamental need for schools of statistics, where the subject is studied for its own sake, where research is carried on, and where teachers gain knowledge and experience. In statistics, as in other subjects, a profession of general practitioners requires the support of an inner circle of specialists, research workers and teachers; and the inner circle maintains its strength partly through teaching and serving the general profession. It is in the university tradition to treat subjects in a broad and fundamental way so as to satisfy the needs as we have stated them; and for this reason we are strongly of the opinion that the teaching of statistics at the professional level should be largely in the hands of the universities. Where this advanced teaching can be associated with an important research school of statistics, considerable advantage will follow.

18. Some universities have developed or are developing advanced schools of this kind. The demand would not justify the existence of such schools at all universities, and it is difficult to form an opinion as to how many there should be, but half-a-dozen is perhaps, at present, sufficient. We do, however, suggest that statistics should in all universities be one of the applied courses for a mathematical degree.

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III. The Types of University Courses.

19. The preceding analysis leads to the conclusion that there should be three main types of course. These will be discussed in the paragraphs of the present section, while comments on the forms of organization required to achieve this programme will be made in Section V.

Elementary Courses.

20. At the lowest level there should be general courses designed to familiarize students with statistical ideas and the most commonly used elementary methods. These should be given in all universities, and should be part of the ordinary undergraduate course of at least all students in the social and natural sciences. The courses need not be very long (10 lectures may well be enough), nor need they require any special mathematical ability; but they should contain some practical work, for practice in the use of statistical methods is a great help to understanding them. This type of elementary instruction is also very necessary for the class of student who comes to the university to take a special course in preparation for work in the public services. It has been found that a number of these students have received at school a quite inadequate training in elementary mathematics and arithmetic. This is a weakness which it is important to remedy if wasted effort is to be avoided by the statistical teacher.

21. Courses of this kind are necessary largely because there is at present little teaching of statistics in schools. If such teaching is extended these university courses could be modified and, ultimately, they may even be abandoned as unnecessary.

Ancillary Courses.

22. According to the present analysis, courses of a somewhat more advanced type are required to enable students to utilize properly statistical methods as developed for application to their chosen science. It is suggested that the syllabus should be designed to teach fully the use of the most commonly employed methods special to the science, and sufficient of their basis to show their limitations; further, it should deal with more advanced methods sufficiently to enable students to recognize when a problem should be referred to a statistician, to co-operate in its solution, and to understand the result. It seems inevitable that there should be separate courses for groups of students specializing in the various sciences. The necessity, at this level, of supplementing lectures by practical work cannot be too strongly emphasized. Without this arithmetic work in the course of training, much of what is taught will be found to have been lost when it is needed as a research tool later on.

23. We believe that it is desirable that this second type of course should be taken by most students of the social and biological sciences in all universities, as part of the normal curriculum for a first degree. We realize that this may be regarded as a revolutionary proposal, and that there are great practical difficulties in adding further work to existing programmes, but it is impossible to escape the conclusion that the scientific worker in the social and biological fields who has not a sound grasp of the statistical approach and its simpler methods of application, is seriously handicapped when appreciating quantitative laws and attempting the interpretation of observational data.

24. As things stand at present only some of the students of physics, chemistry and engineering will wish or need to take statistics beyond the elementary level, and their requirements will probably best be met by providing in more universities postgraduate courses of the kind now available in some places.

Advanced Courses.

25. Advanced courses are probably not required at all universities. Where given, they do and, we think, must, vary in scope and method. At present the University of London is alone in offering a bachelor's degree in statistics, but even in London there is no uniformity in practice at the different schools of the University, and here, as elsewhere, advanced statistics may be included in the undergraduate syllabus within the faculties of mathematics or economics.

26. It is clear that any scheme of training statisticians must include the provision of postgraduate courses. Apart from reasons for this, which apply equally to any subject of study,

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there are certain special reasons holding in the field of statistics which will be referred to in the following paragraphs.

27. The basis of statistical theory and its ally, the theory of probability, is essentially mathematical. Thus, whether a university provides advanced courses in statistics at the undergraduate level or not, a considerable number of graduates with a first degree in mathematics are likely to be attracted to the subject. It is these students, with others of a mathematical bent, who have learnt statistical methods in their undergraduate period, who will form the recruits to the main body of mathematical statisticians who carry on the subject by teaching and research.

28. In certain cases, courses should be organized which, while dealing adequately with statistical theory and method, will aim at treating the application to some special field in an advanced way. Clearly a good preliminary for such a course is a first degree in the subject of application, although competence in mathematics, say, to a pass degree standard is also here necessary.

29. A student who has learnt statistics only from books, lectures and set laboratory exercises, however advanced his knowledge, will not at once make a good statistician. He will need experience—general experience in the use of statistics in solving problems, and special experience in the field of his future activities. The second of these can be obtained only in working life, but the first can, and in our view should, be supplied by the university at the post-graduate level. Where there is an active research school in pure or applied statistics the student can profit much by doing some of the computation and in other ways co-operating in the work in a junior capacity. Alternatively, he can be given some small investigation to complete under supervision. In this connection consideration might well be given to the development of arrangements whereby suitably qualified students can gain practical experience during the long vacation in the surroundings under which real problems must be solved, whether in industrial establishments and research laboratories or elsewhere.

30. We have referred in paragraphs 17 and 18 to the importance of associating research with schools of advanced statistics, and again emphasize our view that provision should be made for this. We would incidentally express the hope that statistics will have its full share of studentships, prizes and similar encouragements for research.

Courses for Extra-mural Students.

31. We would call attention to the thousands of persons, whether graduates or not, who have passed beyond the university stage, and are now at work in this country without having received any training in statistics. As is known from inquiries that have been received, many of these persons are realizing the need for such a training. We ask the universities to consider taking what steps they can to meet this need by establishing short intensive whole-time or part-time courses, which graduates and others already in employment can attend. In large towns such as London this is being done by the arrangement of evening courses. Such courses may have to start at the most elementary first level, but they could profitably be extended to the second level. In so far as some of these persons aim at attaining the External bachelor's degree in statistics of the University of London, opportunities for study at the advanced level may also be required.

IV. Examinations and Diplomas.

32. It is necessary to refer only briefly to the subject of examinations and diplomas. The Council are concerned that all statistical work should be done competently and, as a corollary, that employers should be discriminating in their choice of the people who are to do it. A mark of proficiency in statistics is an aid to this, and it is hoped that all universities which give special courses in the subject will also test the proficiency of their students and mark or give diplomas accordingly.*

* The Royal Statistical Society has recently authorized its Council to cause examinations to be held for the purpose of testing the statistical proficiency of such Fellows of the Society as may desire to submit themselves for examination, and it is hoped that such examinations will shortly be instituted. Every successful examinee will receive a certificate stating the nature of the examination which he has passed.

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V. The Organization of the Teaching of Statistics.

33. On the organization of the teaching of statistics in universities we do not presume to do more than raise some general points.

34. It is strongly recommended that the main teaching in the subject should be the sole responsibility of one or more senior members of the staff, professors or readers, and this for two reasons. First, it is important that statistics should have proper status in the university scheme of things and statistical interests due weight in university counsels. Second, it is essential that the teaching shall be in the charge of men of first-rate ability, highly qualified, able to do original work, enthusiastic for their subject, and willing to make its teaching their career. University teaching in statistics, as in all subjects, should be more than a retailing of second-hand knowledge; its teachers should do original work as well as teach, even where there is no advanced or research school, and the universities should be able to attract their share of the best men in the profession. This they will achieve only if the top posts are commensurate in status with those in other main subjects.

35. A question which has to be faced is whether the teaching of statistics should be centralized in one department or section. It seems indisputable that the teaching of various special branches such as economic "descriptive" statistics, vital statistics and statistical mechanics should be distributed among the appropriate departments. The main principles of statistical theory, the essential elements of probability theory and their methods of application are, on the other hand, basically common to all subjects of application, and there are therefore arguments for and against having them taught centrally.

36. Centralization will tend to give statistics due status in the university. If the teaching is scattered among many departments the subject is apt to be lowly regarded, and the students think it something of a nuisance to be tolerated purely for examination purposes. The right spirit is attained if the teaching is done by authorities in their subject with an enthusiasm for it, and in an atmosphere where statistics matters and is seen to have a life of its own. Moreover, so much of statistical methodology is common to all subjects of application that some centralization is economical; and this argument is specially cogent at this time when qualified teachers of statistics are scarce. Further, the application of statistics in one subject gains from experience of its application in another (many of the methods used in chemical, physical and engineering research came by way of agriculture), and a splitting-up of the teaching is apt to produce sterility in the subject. Students of various faculties who join to attend common statistics lectures also come, incidentally, under the broadening influence of contact with sciences other than their own.

37. On the other hand, centralization, if carried too far, brings with it the danger that the statistical teaching may lose touch with reality. It is important, too, that the statistical way of thought should permeate to the other departments, and that students should not regard it as a kind of special mental gown, to be worn when in the statistics department and discarded on return to their own. To these general arguments against centralization, particular universities will doubtless add special arguments based on special circumstances.

38. The situation calls for compromise, experiment, and variation in treatment. We suggest that each university should establish a recognized centre for statistical methodology. In it could be given all the elementary courses, all the advanced courses on general theory and method, and some of the more special applied courses, particularly those at our proposed second level of advancement. In addition, the separate faculties could have their own statisticians and do some teaching, particularly of special applications. For example, we imagine that all economics and related departments will need their own staff to deal specially with such subjects as index numbers, the analysis of economic time series, and the special problems of sampling in the social and commercial fields; some strong departments of applied biology may profitably employ their own staff to deal with biological experimentation; and some engineering departments may find it advantageous to employ a specialist in engineering and industrial statistics. With a set-up of the kind suggested, the distribution of the teaching between the statistics centre on the one hand and the various departments on the other hand would depend somewhat on the staff available and on other special circumstances, and would vary from one university to another. There might be gradual shifts in responsibility with time as experience is gained and circumstances change.

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39. Whatever the degree of centralization, some statistical work will doubtless be done in several schools or departments of any one university, and the appointment of a joint committee or board of studies to secure co-ordination and co-operation appears essential. This could include representatives of departments that merely use statistical methods as well as of those that teach them.

40. Clearly where an important school for training and research in statistics exists or is planned, it should form an autonomous department. Elsewhere the statistics centre will need to be attached to an existing department, and we think that this should be the mathematics department. Mathematics is at the root of the theory and methods of statistics; moreover, the relation of statistics to other scientific subjects is very like that of mathematics, and similar organizational relationships are appropriate. The latest practice in several universities that are developing statistical teaching is in accordance with this view; at a later date some of these statistics sections will no doubt branch off as independent departments.

41. We have already stressed the importance of practical work as a part of training in statistics, and again emphasize the arithmetical basis of the subject. Unless the student has himself applied the technique developed in lectures to numerical data, the instruction he has received may be largely wasted effort. It is therefore essential that teaching facilities should include statistical laboratories, equipped with computing machines, and fully adequate both for the training of students at the lower levels and for the prosecution of such research as is undertaken.

VI. Inter-University Co-ordination.

42. We are concerned that the standard of teaching and examination in statistics should be uniformly high in all universities, but think that this can be secured through the normal intercourse that occurs between universities, as by exchange of staff and employment of external examiners.

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FIRST REPORT OF THE EXAMINATIONS COMMITTEE, AS AMENDED AND ADOPTED BY THE COUNCIL

The Certificate in Statistics

1. THE Committee were appointed by the Council, on Wednesday, November 13, 1946, to prepare proposals arising out of the new Bye-law No. 38, which runs as follows:

> "The Council may at any time cause examinations to be held for the purpose of testing the statistical proficiency of such Fellows as may desire to submit themselves for examination. The Council shall determine the subjects to be comprised in such examinations, the manner in which such examinations shall be conducted, the fees to be paid to examiners, whether Fellows or not, and the fees to be paid by examinees. Such examinations shall be open to every Fellow, and every successful examinee shall be granted a certificate stating the nature of the examination which he has passed."

2. The Committee consisted of Mr. M. G. Kendall (Chairman), Professor R. G. D. Allen, Mr. D. J. Finney, Mr. R. F. George, Professor Major Greenwood, and Dr. David Heron.

3. The Committee had no specific terms of reference; they therefore interpreted the instructions of the Council fairly widely. They considered their task to be the preparation of a detailed scheme for conducting examinations, including a set of governing regulations and a syllabus. The original proposals of the Committee under the Chairmanship of Dr. Snow recommended an examination at two levels. At the lower level successful candidates would receive a Certificate, at the higher a Diploma. The present Committee have also considered separate examinations for a Certificate and a Diploma. The examination at the Diploma level, however, is a much more difficult matter to plan in detail than that of the Certificate, and in order to save time the Committee present herewith a first Report which relates only to the Certificate. A second Report on the Diploma will be submitted as soon as possible. Since candidates will normally take the Certificate before proceeding to the Diploma, examinations for the Certificate could be instituted before those for the Diploma.

Regulations

4. The Committee propose that the examinations should be conducted under the Regulations which are attached. These have been drafted after a careful study of the Regulations for several other examinations already in existence.

5. The only point on which the Committee wish to comment is that of exemptions. They have very carefully considered the desirability and practicability of allowing exemptions from parts of the Certificate examination, and have come to the conclusion that none should be granted. The main argument in favour of exemption is that the candidate seeking it is already of the standard required, and therefore should not be asked to waste time in submitting himself to a fresh examination. But this argument has two edges, for a candidate who already has the ability to pass the examination does not suffer serious hardship from the requirement that he should take it. Nor will the expense be great. On the other hand, the arguments against exemption appear to the Committee to be so strong as to be decisive. The examination standards vary very much from one institution to another and to specify exemptions would throw on the Society the invidious task of expressing an opinion on the standards of certain outside examinations. The Committee think that the only rule which will avoid complication and dispute is to permit no exemptions.

Syllabus

6. In preparing the Syllabus, the Committee have been guided by the provisional Certificate Syllabus prepared by Dr. Snow's Committee. They have followed the general lines indicated in that Syllabus, but have made a number of modifications, of which the following are the most important:

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(*a*) The Syllabus has been amplified in order to make its scope clearer;

(*b*) there has been some rearrangement of the items in the four proposed sections;

(*c*) an essay has been incorporated in one of the papers in order to test the candidate's ability to write clear and connected English on a statistical subject with which he is familiar;

(*d*) for the present, the ability to handle calculating machines will not be tested. The main reason for this is the practical difficulty of carrying out adequate tests, particularly during the present scarcity of machines;

(*e*) special papers on the application of statistical methods to particular fields (Group B in the syllabus suggested by Dr. Snow's Committee) will not be set for the Certificate.

7. In accordance with the recommendation of Dr. Snow's Committee, evidence of practical experience will not be required at the Certificate level. The question of practical experience is more material for the purposes of the Diploma, and will be discussed in the Committee's second Report.

8. The proposed Syllabus is attached to this Report as Appendix I to the Regulations. In order to exhibit more clearly the scope of the Syllabus and the standard which they have in mind, the Committee have prepared specimen examination papers, which are attached as Appendix II to the Regulations. The Committee recommend that these papers be published with the Syllabus in order to guide candidates who submit themselves for the first Examination. (The Council are reminded that a candidate would not be expected to answer every question in any paper, but could obtain full marks by completing six questions out of the ten proposed.)

Reading

9. It has been stated on the Society's behalf on several occasions that in formulating proposals for examinations for its Fellows the Society has no intention of providing courses of instruction or of engaging in any form of teaching. Nevertheless the Committee feel that the Council might properly give some help to candidates in planning their studies. They suggest that the permanent Examinations Committee, if set up in accordance with the recommendation in paragraph 13 below, should be asked to advise the Assistant Secretary in dealing with applications from Fellows for assistance in the choice of reading for the Certificate.

Procedure

10. The Committee recommend that their proposals (after such modification as the Council may desire) be brought into effect as soon as possible, and that examinations for the Certificate be held in December, 1947, September, 1948, and April, 1949. The Committee suggest that, in subsequent years, Certificate examinations should normally be held in April. It is desirable, however, to initiate the examinations before April, 1948, and the above dates are suggested as the most reasonable which will allow the normal date to be reached by 1949.

11. The Committee have considered whether examinations should be conducted in the Provinces. They think that, in the first instance, the examinations should be held in London only, but it would be easy to provide for holding them elsewhere in future if necessary.

12. The Committee suggest that their proposals (after modification and approval by the Council) be circulated to all Fellows, with a request that any who wish to submit themselves for examination at one of the above-mentioned dates should notify the Assistant Secretary immediately. This indication of intention would be entirely without prejudice to their later actions, but would greatly help officers of the Society to gauge the probable numbers of candidates in the first few years.

13. If the Committee's proposals are approved, a permanent Examinations Committee will be required for supervision of the holding of examinations and for dealing with matters relating thereto. The present Committee therefore recommend that the Council of the Society appoint such a Committee as soon as proposals for the Certificate examination have been adopted. The Committee should be empowered also to supervise the Diploma examinations when these are established.

(Signed) MAURICE KENDALL,
Chairman.

May, 1947.

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General Regulations for the 1947 Certificate Examination for Fellows

1. In accordance with Bye-law No. 38, the Council has decided to institute examinations for the purpose of testing the statistical proficiency of such Fellows as may desire to submit themselves for examination.

Dates of Examination

2. The first examination will be held in London, on December 19th and 20th, 1947, and will be for the Certificate of the Society.

Details of Examination

3. The syllabus of the examination, and specimen examination papers, are given in Appendices I and II.

The examination will be conducted by printed papers and will be a pass examination only; lists of successful candidates will be published in alphabetical order, without division into classes.

The Certificate of the Society will be awarded to candidates who satisfy the examiners in all four Sections of the examination provided that both of Sections A and B are passed at one and the same examination, and that both of Sections C and D are passed at the same or at a previous or subsequent examination. No Fellow may enter for Sections C and D unless he has already passed in Sections A and B or is entering at the same time for Sections A and B. The Certificate of the Society will be signed by the President or one of the Vice-Presidents, and by one of the Honorary Secretaries.

Every Certificate Examination will be conducted in accordance with the Regulations and Syllabus in force at the time of entry for the examination.

Entry to Examination

4. Every Fellow who desires to enter for the 1947 Certificate Examination must apply to the Assistant Secretary of the Society, at 4, Portugal Street, London, W.C. 2, for an Entry Form. He must then send the Entry Form, accompanied by a remittance for the appropriate Fee, to the Assistant Secretary, so as to be received not later than October 15th, 1947. Candidates are requested to send in their Entry Forms as early as possible; no Entry Form received after October 15th, 1947, will be accepted for the 1947 Certificate Examination.

Fees

5. The Fees payable in respect of the 1947 Certificate Examination are:

For Sections A and B	£2
For the whole Examination (Sections A, B, C and D) . .	£4

All cheques, money orders and postal orders should be made payable to the Royal Statistical Society and crossed.

Withdrawal from Examination

6. If, after entry for the 1947 Certificate Examination and the payment of the appropriate fee, a candidate withdraws his name or fails to present himself for examination, no part of the fee paid will be returned to him, but (*a*) if notice of withdrawal is received not later than November 10th, 1947, or (*b*) if a candidate on account of illness fails to present himself for examination or retires from the examination, and furnishes not later than January 31st, 1948, satisfactory medical evidence of illness at the time of the examination, the fee paid will be carried forward to the 1948 Certificate Examination.

Time Table of Examination

7. The examination will be conducted at the place, at the hours, and in the order shown on the Time Table, which will be sent to every candidate about a month before the commencement of the examination. Any candidate who has not received a copy of the Time Table by November 20th, 1947, should at once communicate with the Assistant Secretary.

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Notification of Results of Examination

8. A copy of the Pass Lists will be sent to every candidate. Every unsuccessful candidate will also receive, as soon as may be after the issue of the Pass Lists, a report on the standard which he attained in each Section of the examination for which he entered, on the following basis:

A. Good Pass.
B. Pass.
C. Failure.
D. Bad Failure.

Exemption from Examination

9. No candidate will be exempted from the whole or from any Section or Sections of the Certificate Examination on the ground that he has passed another examination, or on any other ground.

Interpretation

10. The decision of the Council on the interpretation of any provision of the Regulations and Syllabuses of the Certificate Examination shall be final.

APPENDIX I

Syllabus of the 1947 Certificate Examination for Fellows

To obtain the certificate candidates must have passed the four sections A, B, C and D below.

One paper of three hours will be set in each section.

The mathematics required will be approximately of the standard of Elementary Mathematics in the Matriculation Examination of London University, and the emphasis will be on statistical methods and ideas rather than on mathematical analysis.

Squared paper and logarithm tables will be supplied. Candidates may use their own slide rules.

Section A

Nature and scope of statistical inquiries.
Design of questionnaires.
Classification and tabulation; continuous and discontinuous variation.
General acquaintance with official statistics and other sources of existing material.
Errors and defects in published material. Pitfalls in interpretation.
Graphical presentation of results.
Elementary statistical reasoning.

Section B

Descriptive properties of frequency distributions.
Nature and calculation of averages and measures of dispersion—means, medians, modes, quartiles, interquartile range, standard deviation.
Elementary theory of index numbers.
Association, contingency and the elements of linear regression and correlation (partial and multiple correlation and regression not required).
Elements of interpolation and graduation.
The fitting of straight lines and parabolas.
Elementary analysis of time-series; moving averages, trend lines (but not analysis of oscillatory movements).

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Section C

Elements of probability as applied to statistics.
Sampling methods.
Properties of the binomial, Poisson and normal distributions.
Sampling error. Standard errors of commoner statistical measures.
Tests of significance and goodness of fit; simple applications of the χ^2, t and z tests. (Proofs will not be required.)
Elements of experimental design and analysis.
Elements of statistical quality control.

Section D

(1) An essay on one of a number of general statistical subjects.
(2) Practical exercises in the application of the methods covered by Sections A, B and C to the analysis of numerical data.

Specimen Papers of the Certificate Examination for Fellows

Section A

(Three hours. Full marks may be obtained on six questions, and not more than six should be attempted)

A. 1. You are asked to investigate whether, at some specific health resort, wet springs tend to be followed by dry summers. How would you proceed?

A. 2. Draft a questionnaire to be addressed to owners of motor cars in a particular district to ascertain the annual cost of running a car. You may assume that the information required is covered by itemized figures for petrol, oil, repairs, cleaning, garage, taxes, insurance and sundries, and that, in order to enable depreciation to be taken into account, information is also required about the age of the car and its purchase price.

A. 3. The following table purports to show the value of imports of live animals for food into the United Kingdom for 1921–28 inclusive. Criticize the layout of the table, redraft it in what you regard as a preferable form and comment on the data.

British Imports of Animals, 1921–28

	1921.	1922.	1923.	1924.
Numbers . . .	77,000	49,000	1,236,000	1,834,000
Value . . .	£2,804,000	£1,580,000	£14,029,000	£22,049,000

	1925.	1926.	1927.	1928.
Numbers . . .	1,298,000	1,422,000	1,616,000	1,635,000
Value . . .	£17,576,000	£16,982,000	£15,510,000	£16,634,000

A. 4. Describe the main features of the *Monthly Digest of Statistics*, prepared by the Central Statistical Office.

A. 5. In any *four* of the following, state what sources you would consult to obtain numerical data and give particulars of the information you would obtain:

(*a*) Imports of sugar from Mauritius into the U.K.;
(*b*) the number of farms in England and Wales;
(*c*) the revenue of the Exchequer from excise duties on beer;
(*d*) the death-rate of Manchester;
(*e*) changes in cost of living in the last six months;
(*f*) the number of individuals with incomes above income-tax exemption limit.

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A. 6. According to English Life Table No. 10 (mortality experience of 1930/2) the complete expectation of life at birth for males was 58·74 years. According to English Life Table No. 3 (mortality of 1838–54) the complete expectation of life at birth for males was 39·91 years. Would it be correct to deduce that men may expect to live more than 18 years longer than their grandfathers?

A. 7. Give an account of British statistics of unemployment, and state some precautions to be observed in interpreting them.

A. 8. A pictorial comparison of populations in different countries is made by drawing for each country a picture of a man whose height is proportional to the population of that country. Would you say that this was a sound method? If not, what alternatives would you propose?

A. 9. Consider the inferences in two of the following statements, and state what further information you would require to examine the correctness of the conclusions:

(*a*) That the British Mercantile Marine has declined may be judged by the fact that there were 2,000 fewer vessels under the British flag in 1939 than in 1913.

(*b*) In 1941 the crude civilian death rate in Brighton (excluding war deaths) was 16·1, and in Wigan was 13·7, so that Wigan must have been a healthier place than Brighton.

(*c*) In 1937 the exports in quantity of wheat from the U.S.A. to the U.K., as shown in the U.S.A. trade returns, were not equal to the imports of wheat into the U.K. from the U.S.A. as shown in the U.K. trade returns; so the returns for one country or the other, or both, must be inaccurate.

A. 10. Sons of fathers who are taller than the average are themselves taller than the average, though not so tall as their fathers on the average. On the other hand, fathers of sons who are taller than the average, though taller than the average, are not so tall as their sons on the average. Why are these statements not contradictory?

Section B

(*Three hours. Full marks may be obtained on six questions, and not more than six should be attempted. Slide rules may be used where suitable. Squared paper and tables of logarithms and squares will be supplied. All arithmetical work must be shown*)

B. 1. Define a frequency distribution, and give an account of various methods of illustrating it graphically, indicating the merits of the different methods for different types of data.

B. 2. Find the arithmetic mean and the standard deviation of the following distribution:

Legitimate Maternities with Twin Births, 1941, *England and Wales*

Age of mother at last birthday (years).	Number of births.
15–	264
20–	2,326
25–	3,990
30–	3,572
35–	2,412
40–	678
45–	20
Total	13,262

B. 3. Draw a cumulative frequency curve of the data in Question B. 2 and use it to estimate graphically the median and the quartiles.

Comment on the accuracy of your results.

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B. 4. Explain what steps are taken in compiling index numbers, (*a*) to remove the effect of seasonal fluctuation, and (*b*) to isolate seasonal fluctuation for separate study.

B. 5. The following figures show the population of England and Wales in certain years:

Year.	Population (millions).
1811	10·16
1821	12·00
1831	13·90
1841	15·91
1851	17·93

By the use of any method known to you, estimate the population in 1825 and 1845.

B. 6. An experiment is conducted to verify the law of falling under gravity expressed by

$$s = \tfrac{1}{2}gt^2$$

where s is the distance fallen at time t and g is a gravitational constant. The following results are obtained:

t (seconds)	1	2	3	4	5
s (feet)	15	70	140	250	380

Plot s against t^2 and draw a straight line which passes approximately through the points. Taking s as the dependent variable, fit a straight line to the data by the method of least squares and hence estimate g.

B. 7. Explain the use of a logarithmic scale in graphing certain kinds of time series, and give one example of the type of data for which it is useful.

B. 8. The following series shows for U.K. total imports, (*a*) the declared value, and (*b*) the value on the basis of average values in 1930.

U.K. Total Imports

Year.	Declared value (£ million).	Value on basis of 1930 values (£ million).
1930	1,044	1,044
1931	861	1,067
1932	702	939
1933	675	946
1934	731	991
1935	756	1,012
1936	848	1,077

Taking 1930 as a base year, construct index numbers (1) of average values and (2) of volume for the years 1931–6.

B. 9. The following series shows (1) the total number of notified mental defectives per 10,000 of population in England and Wales, and (2) the number of wireless receiving licences issued during the year in the U.K.

Year.	Number of defectives per 10,000 of the population.	Number of licences (millions).
1924	8	1
1925	8	2
1926	9	2
1927	10	2
1928	11	3

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Year.	Number of defectives per 10,000 of the population.	Number of licences (millions).
1929	11	3
1930	12	4
1931	16	5
1932	18	5
1933	19	6
1934	20	7
1935	21	8
1936	22	8
1937	23	9

Show that the product-moment correlation coefficient between (1) and (2) is 0·98. What significance do you attribute to this result?

B. 10. Explain the use of moving averages in determining the trend line in a time series.

Determine such a line in the following series of values by the use of a simple moving average of seven consecutive terms:

Year.	Index number of coal export prices.
1924	187
5	161
6	149
7	142
8	125
9	129
1930	133
1	127
2	130
3	129
4	129
5	130
6	136
7	152
8	171
9	169
1940	218
1	258
2	279
3	295
4	314

Would you say that this was a satisfactory line of trend? If not, why not?

Section C

(Three hours. Full marks may be obtained on six questions, and not more than six should be attempted. Slide rules may be used where suitable. Squared paper and tables of logarithms and squares will be supplied. All arithmetical work must be shown)

C. 1. Five cards are drawn at random from an ordinary pack of 52 playing cards. Find the probabilities

(*a*) that they are all of the same suit;

(*b*) that four of them are of one kind (e.g. four aces).

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C. 2. Discuss the basis of a quality control chart appropriate in the case where the quantity considered is the fraction of items defective in a sample of n items.

Suppose that an item is regarded as defective when a variable x, capable of exact measurement, e.g. a measure of strength, falls below a specified value x . Discuss reasons for or against using a control chart based on, (*a*) $\bar{x}$, the mean value of x in a sample rather than on (*b*) the fraction defective.

C. 3. Show that for the binomial distribution $(q + p)^n$ the mean is np and the variance npq. What is the use of the latter result in sampling for attributes?

C. 4. Sketch the normal curve

$$y = ke^{-\frac{1}{2}x^2}$$

What is the value of k to make the area under this curve unity?

Why is the curve of great importance in the theory of sampling?

C. 5. A random sample of 100 potatoes harvested from one field has a mean weight of 5 ounces with a standard deviation of 1·5 ounces. A random sample of 150 potatoes harvested from a second field has a mean weight of 4·5 ounces with the same standard deviation. Discuss whether the mean weight of potatoes harvested from the two fields differs significantly.

C. 6. A sleeping-draught and a neutral control preparation were tested in turn (in random order) on ten patients at a hospital, and gave the following results:

Patient.	Number of hours of sleep. Drug.	Control.
1	10·6	8·6
2	7·5	7·3
3	9·0	9·4
4	5·4	5·1
5	6·1	5·4
6	10·2	9·0
7	7·1	6·5
8	9·7	7·9
9	8·5	8·7
10	7·9	6·9

Calculate the appropriate value of t to test whether the drug has any greater effect than the neutral control preparation, stating the number of degrees of freedom and indicating how you would determine the significance from a table of the t-distribution.

C. 7. Define statistical independence. Derive an expression for the variance of the sum of a number of independent variables. Why is the variance of the sum of two independent variables the same as the variance of their difference?

C. 8. The following table shows the number of recruits taking (1) a preliminary and (2) a final test in car driving:

		Preliminary Pass.	Fail.	Totals.
	Pass	605	135	740
Final.	Fail	195	65	260
	Totals	800	200	1000

Use the χ^2 test to discuss whether there is any association between the results of the preliminary and those of the final test.

The following are certain probability levels for χ^2.

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Probability level.	Degrees of freedom.			
	1.	2.	3.	4.
10%	2·71	4·60	6·25	7·78
5%	3·84	5·99	7·82	9·49
1%	6·64	9·21	11·34	13·28

C. 9. Fit a quadratic parabola to the following series of observations, taking the year as the independent variable:

Year.	Index of coal export prices.
1924	187
7	142
1930	133
3	129
6	136
9	169
1942	279

Use your results to estimate the value of the index for 1935.

C. 10. What sources of bias would you wish to guard against in a sampling inquiry into two of the following?

(*a*) A house-to-house inquiry into the consumption of milk in households;
(*b*) a crop-cutting inquiry to determine the mean yield of barley in England and Wales;
(*c*) a broadcast request for listeners to submit their views on the Third Programme;
(*d*) a straw vote in a constituency to forecast the result of an election.

Section D

(*Three hours. Answer the essay question D.* 1, *to which not more than one hour should be devoted, and any* two *of the remaining questions, D.* 2 *to D.* 5. *Slide rules may be used where suitable. Squared paper and tables of logarithms and squares will be supplied. All arithmetical work must be shown.*)

D. 1. Write an essay on *one* of the following:

(*a*) Sampling human populations.
(*b*) What is a "flair" for figures?
(*c*) Accident statistics.
(*d*) The statistics required for Town and Country Planning.
(*e*) The use of control charts in engineering.
(*f*) Occupational mortality rates.
(*g*) The size and shape of plots in agricultural field experiments.
(*h*) The occurrence of the normal distribution in biological material.
(*i*) The (proposed) Census of Distribution.
(*j*) The reasons for randomization and replication in experiments.

D. 2. The weekly average traffic receipts of the main line railways passenger trains and the L.P.T.B., for 1935–46, were: (£000), 1935, 1,847; 1936, 1,898; 1937, 1,954; 1938, 1,972; 1939, 1,967; 1940, 1,998; 1941, 2,526; 1942, 3,135; 1943, 3,562; 1944, 3,728; 1945, 4,028; 1946, 3,868. The weekly average loaded train miles for the same years (in millions) were respectively: 4·99, 5·09, 5·20, 5·28, 4·73, 3·66, 3·69, 3·71, 3·73, 3·67, 3·94 and 4·34. The annual average wholesale price index numbers for the same years (1938 = 100) were respectively: 87·7, 93·0, 107·2, 100·0, 101·4, 134·6, 150·5, 157·1, 160·4, 163·7, 166·7 and 172·7.

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Correct the traffic receipts to 1938 values by applying the wholesale price index number, and calculate for each year the receipts in £ at 1938 values per loaded train mile.

Draw time graphs, on the same chart, of (*a*) the receipts at 1938 values, (*b*) the weekly average loaded train miles, (*c*) receipts at 1938 values per loaded train mile.

D. 3. The following table shows the annual net income for 162 white families in Norfolk-Portsmouth, Virginia, and for 419 white families in Baltimore, Ohio, in 1934–36:

Annual net income. $	Number of families. Norfolk-Portsmouth.	Baltimore.
300–	..	4
600–	10	45
900–	23	95
1,200–	40	120
1,500–	32	67
1,800–	28	51
2,100–	20	17
2,400–	4	9
2,700–	2	5
3,000–	1	3
3,300–	2	2
3,600–	..	1
	162	419

Calculate for each town separately—

(*a*) the mean income;

(*b*) the standard deviation of the income of a single family;

(*c*) the standard error of the mean, on the assumption that the families included are a random sample of the white families in the town.

Hence, calculate the standard error of the difference of the two mean incomes, and show that these differ significantly.

D. 4. A field experiment to test the effect of superphosphate and Gafsa rock phosphate on potatoes was laid out in a Latin square with the following treatments:

A. No phosphate.
B. 0·33 cwt. P_2O_5 per acre } as super.
C. 0·66 ,, P_2O_5 ,, }
D. 0·50 ,, P_2O_5 ,, as Gafsa.

The area of each plot was 1/50 of an acre. The plan and yields in pounds per plot were as follows:

C: 312	A: 232	B: 298	D: 300
D: 305	B: 305	A: 248	C: 324
A: 256	D: 317	C: 330	B: 312
B: 343	C: 343	D: 320	A: 271

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Carry out an analysis of variance of these results, and give a table showing the mean yield in tons per acre with each of the four treatments and the standard error of these means.

Comment on the results.

D. 5. The following table shows the percentage ash-content of coal taken from 150 wagons grouped, on a time basis, into 30 consecutive samples of 5. Make control charts for the mean and the range, marking the appropriate control limits; discuss the results.

You are given that for random samples of 5 from a normal distribution with standard deviation σ,

$$\text{Mean range} = 2{\cdot}33\,\sigma.$$

1 sample in 1,000 may be expected to have range { below $0{\cdot}37\,\sigma$. above $5{\cdot}48\,\sigma$.

25 samples ,, ,, ,, ,, { below $0{\cdot}85\,\sigma$. above $4{\cdot}20\,\sigma$.

Sample No.	1	2	3	4	5	6	7	8
	16·7	17·6	18·2	14·4	15·8	9·3	19·7	17·3
	16·2	14·9	21·5	22·9	14·3	16·4	17·1	21·0
	18·3	12·6	17·9	17·5	17·1	20·7	13·0	18·7
	14·5	15·5	21·2	19·4	13·6	23·8	10·6	16·9
	12·0	17·9	14·2	17·4	13·2	15·0	18·1	13·9

Sample No.	9	10	11	12	13	14	15	16
	21·1	17·6	11·4	21·2	18·6	21·9	19·8	14·3
	18·3	13·2	14·7	18·0	22·7	13·9	21·8	17·8
	16·2	21·3	12·7	18·8	17·3	25·4	19·5	14·5
	19·8	17·6	17·6	16·9	16·3	19·6	18·5	14·1
	13·5	17·0	15·5	18·8	17·7	23·7	19·1	15·5

Sample No.	17	18	19	20	21	22	23	24
	17·9	16·7	18·0	15·7	18·3	20·2	10·4	15·8
	14·4	16·5	16·2	12·2	12·2	14·3	16·3	15·4
	17·8	14·7	14·5	16·1	16·8	17·8	16·5	18·6
	14·6	16·3	13·6	13·2	21·0	17·0	18·0	17·0
	18·8	17·8	14·6	14·0	17·9	14·9	11·9	12·4

Sample No.	25	26	27	28	29	30
	16·4	17·0	18·0	15·1	19·2	17·2
	14·4	17·1	18·5	19·0	16·4	15·1
	16·0	18·4	18·3	18·4	17·9	19·8
	14·6	16·0	16·4	18·5	18·5	16·5
	20·8	17·5	16·9	17·5	15·1	14·0

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Regulations of the Study Section

The detailed regulations for the conduct of the Study Section of the Society have been finally approved by the Council, and the full text is printed below.

Organization

1. The Section shall be constituted and carried on subject to the Bye-laws of the Society, and in accordance with these Regulations, made and subject to amendment by the Council of the Society. The Section shall be concerned with the study and informal discussion of statistical subjects.

Membership

2. Any Fellow of the Society and any other person who is approved by the Section Committee may become a member of the Section on making written application to the Section Secretary.

3. A Fellow of the Society shall not be required to make any payment for membership of the Section, but every other member shall pay an annual subscription of ten shillings, which shall be due in advance on January 1, provided that any person who becomes a member and pays his initial annual subscription in the last quarter of any year shall not be required to pay any subscription in respect of the following year. Subscriptions shall be payable direct to the Honorary Treasurer of the Royal Statistical Society, 4, Portugal Street, W.C. 2.

4. If any member of the Section has not paid his annual subscription by June 30, the Assistant Secretary of the Royal Statistical Society shall advise him in writing of the default, and if the arrears are not paid up by September 30, the defaulter shall cease to be a member.

5. Payment of an annual subscription in respect of membership of the Section shall not confer on the member any of the privileges of Fellowship of the Society.

6. Members who are not in arrears with their annual subscriptions may withdraw from membership by giving written notice to the Section Secretary.

The Section Committee

7. Subject to these Regulations, all the affairs of the Section shall be directed by a Section Committee consisting of two Fellows nominated by the Council of the Society and six members elected by the Section.

8. (*a*) At least two of the six members of the Section Committee elected by the Section shall retire annually and shall not be eligible for re-election for the period of one year. The Committee shall decide on the members to retire, and in doing so shall have regard to seniority on the Committee and degree of attendance. No elected member may serve continuously on the Committee for more than four years.

(*b*) The Section Committee shall nominate members for election to the Committee for the following session, and these nominations shall be circulated to all members at least a month in advance of the date of the last Ordinary meeting of the Section in the current session. Members of the Section, if they so desire, may nominate further candidates (being members of the Section) for election, in which case a ballot shall be taken at the meeting. Candidates so nominated must be proposed and seconded by members of the Section, and nominations must be received in writing by the Secretary of the Section at least a week before the date of the meeting.

9. The Section Committee shall elect a Chairman and Secretary from among its members. These two officers shall retire after a year of office, but are to be eligible for re-election.

10. (*a*) The Section Committee shall arrange meetings of the Section for reading of papers, lectures and discussions.

(*b*) The Section Committee may form study circles for the examination and study of particular problems if it considers that a sufficient number of persons have indicated their willingness to participate in the study circle.

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(*c*) Any member of the Section may suggest, in writing to the Secretary of the Section Committee, that a study circle be formed to study a certain subject. The Section Committee shall then decide whether such a circle should be formed or not.

11. The Section Committee may recommend that any papers read before the Section or produced by a study circle shall be published by the Society or filed in its Library for reference.

12. The Section Committee shall send to the Assistant Secretary of the Society not later than November 1 in each year (i) an itemized estimate of the total expenditure of the Section in the current session with a request for funds to meet such expenditure, and (ii) a detailed statement of the expenditure of the Section in the past session, with vouchers.

A report of the activities of the Section in the current session and some account of the papers, lectures, discussions and study circles arranged by the Section shall be sent to the Assistant Secretary of the Society not later than May 31 in each year.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

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1.—*Time Series Analysis: Smoothing by Stages.* By Lewis A. Maverick. San Antonio, Texas: Paul Anderson Co., 1945. 10″ × 8″, x + 153 pp.

1. Teachers of economic statistics have become accustomed to suggesting that the movements of an extensive series, such as monthly coal production over a century, may be analysed into components such as the following:

(i) The long-term trend,
(ii) cycles of period twenty years or more,
(iii) short- or business-cycle,
(iv) regular seasonal variation,
(v) irregular monthly movements.

During certain periods such as the nineteenth century in Great Britain, the expansion of population and trade has been so rapid as to provide the illusion that the long-term trend of many production series has been upward at an established and steady geometric rate. Again, in the same period, a succession of crises at intervals of approximately ten years has provided the illusion that in many series of production and prices, the business cycle was a regular phenomenon of steady period and proportionately steady amplitude.

The disturbed history of the twentieth century has for many of us shattered these illusions, and suggested that only in the seasonal variations are we likely to find any regularity, and that the pattern even of these will gradually change.

2. Accordingly in class-work with economic statisticians, emphasis has come to be placed on

(i) the separation of seasonal variations,
(ii) the fitting of trend curves in order to shorten the description of long time series.

The separation of cycles now receives less emphasis, although this may be done in order to discover whether the cyclical movements of a particular series lag behind, or lead those of another series such as the unemployment percentage.

3. The separation of trend, cycles, seasonal and other variation may sometimes enable us to relate the movement of our series to that of other series by means of regression analysis. For example, the trend of coal output might be related to such series as population, railway traffic trend, export volume trend, oil imports, etc.; its cycles might be geared to those of pig-iron prices, U.S.A. coal imports, etc., and the numerical constants and lags in these relations could be estimated by familiar techniques; finally, the seasonal pattern may be regular, or demonstrably related to other phenomena such as mean temperature, the number of working days and the imminence of public holidays.

In the rare cases where the other series have been forecast for some years ahead, or where our own series lags behind the others, it is possible to use these observed relations to obtain a rough forecast of our own series.

For example, during the war a fairly close relation was observed between the number of a certain type of aircraft coming in for repair and the total strength of that aircraft 3 months earlier. This relation varied systematically with the seasons. Since the future strength of the aircraft was forecast, and sufficient was known of policy in its use to warrant the supposition that these relations would continue, its future input to repair could be roughly forecast.

4. Owing to the fact that it is usually equally difficult to forecast the series on which our particular series may depend, the splitting of our series into trend, cycles, seasonal and other variation

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often only helps us to forecast by suggesting a continuation of the seasonal pattern. That is why teachers now place most emphasis on the separation of seasonal variation. But the analysis of annual data into trend and cycles still may provide a convenient exercise in the handling of least-squares formulae, and a comparatively painless method of introducing the student to statistical sources.

On the few occasions where such an analysis is going to be seriously used, it is of course important that the methods employed should be sufficiently standardized as largely to eliminate the personal bias of the investigator. The method of analysing by *merely* drawing freehand graphs is much the quickest, and probably sufficient for nearly all practical purposes: but as a basis of figures for convincing other people, this method has its drawbacks, and so there have been devised the various algebraic methods which achieve objectivity at the expense of much time and elasticity.

5. The "statistical clerk" is now provided with a method which retains many of the advantages of the freehand-curve method whilst being sufficiently standardized to eliminate most of his personal bias. "Smoothing by stages" is "concerned with trends or smoothing lines and with cycles. In difficulty it is designed for the student or statistical clerk who has had but little training in statistics. He should have fitted straight line trends by least squares, and have calculated seasonal indexes and the normal line; he should be familiar with the use of the normal line as a base of reference in studying business cycles; he should have plotted time-series, trends, and moving averages on quadrille paper; and he should be ready to form conclusions as to the relative advantages, as trends, of the straight line and sundry curves."[1]

This warning must not alarm the reader of "Smoothing by stages" who is determined to master the subject. For the book is clearly written and explains in detail just how to break a series up into trend, long-cycle, short-cycle, seasonal variation and residuals, and even how to make a forecast by extrapolation.

Your reviewer armed with a pencil and graph book spent a happy evening in a deck chair trying out the method. On the basis of the figures of "San Francisco Real Estate Activity," 1900–1930, he achieved the forecast for 1931–1940 given below. A comparison with the actual figures shows that it was not a very lucky forecast, but no one in their senses would expect to be able to make a useful forecast merely on the basis of such data.

San Francisco Real Estate Activity

(Hundred deeds)

Year	*Activity*	*Year*	*Activity*	*Year*	*Activity*	*Year*	*Activity*	*Forecast activity*
1901	33	1911	82	1921	97	1931	85	86
1902	43	1912	79	1922	125	1932	71	69
1903	58	1913	67	1923	149	1933	52	71
1904	64	1914	62	1924	157	1934	44	91
1905	71	1915	55	1925	183	1935	58	114
1906	96	1916	66	1926	165	1936	79	140
1907	89	1917	60	1927	130	1937	87	170
1908	82	1918	48	1928	110	1938	82	200
1909	74	1919	71	1929	94	1939	89	230
1910	85	1920	92	1930	85	1940	107	230

Or would they? The danger in publishing this book is that they might, in spite of the repeated warnings that such forecasts are "not infallible." Statistical clerks on the average would probably apply the method no more successfully than your reviewer, and yet in some cases important decisions might be based on their forecasts, and what is worse, many valuable statistical-clerk-hours would have been wasted on a pointless task.

The main defect of this book is that it may lead the unwary to suppose that the past figures of a single economic time series *alone* provide the material for forecasting its future. A secondary defect is that no reference is made to the possibility of using correlograms in such analysis.

6. Assuming, however, that analyses of time-series into trends, cycles, etc., do have, for some unspecified reason, to be made, are the methods here suggested good ones?

The answer is that the suggested methods do provide a practical compromise between the arbitrariness of freehand graphs and the rigour of least-squares procedures. Any qualified reader is likely to have various improvements to suggest, but on the whole the methods chosen are sensible ones.

[1] In this country such attainments are of course rare.

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There are, however, one or two minor criticisms which can yet be made. The author overestimates the extent to which the statistical clerks will agree in their estimate of the "business cycle." It is notorious that different statistical techniques applied to twentieth century data can reveal short cycles of any length from three to twelve years, because, of course, there seldom is really any regular cycle at all. "Smoothing by stages" suggests a first approximation by a freehand curve to smooth away the business cycle: the clerk then proceeds to a better approximation by a moving average of varying period based on an estimate of the trade cycle period, itself depending on the freehand curve. This means that the clerk's freehand curve has a lot to do with the length of business cycle which he will eventually detect.

Again, insufficient attention is paid to seasonal variation. The author is to be congratulated on recognizing that cycles are unstable phenomena, and therefore allowing the length of his moving average to vary when separating the cycles; but why does he not instruct the clerk in allowing for variations in the seasonal pattern as well? It is a grave disadvantage that no indication whatever is given of how to gauge the margin of error of a forecast; nor does the author compare any forecast with subsequent events.

His methods always involve investigating the short cycles first; it is not altogether clear why this order has been chosen, yet there may be good reasons. However, the estimate of the short cycles would often be made much easier, if as a *preliminary* step a freehand (long-term) trend curve were fitted by using a flexible metal rule and the data all measured as deviations from that trend. Ripples, very difficult to detect on a steeply-rising curve, may thus be brought into perspective.

The book is well provided with applications of the method to actual series, and can be recommended to those who often need to analyse time-series into their supposed components, and require clear instructions for performing the task. D. G. C.

2.—*An Experimental Introduction to the Theory of Probability*. By J. E. Kerrich. Copenhagen: Munksgaard, 1946. $9\frac{1}{2}'' \times 6\frac{1}{4}''$. 98 pp. *Dan. kr.* 8.50.

All those who have been introduced to the foundations of the theory of probability must have tried at some time or other to envisage what it looked like exactly when ratios were computed step by step from an actual experiment in random events. Lack of time might have prevented us from passing to a real experiment from an imagined one. The author had ample time, nor did he apparently suffer from impatience. As a British subject he was, for his own safety, interned by the Danish authorities when their country was occupied by the Germans, and we can well imagine the soothing effect of spinning a coin 10,000 times, or drawing 5,000 times two balls out of four while the time scale seems to stretch to infinity. (The latter feat was performed by a fellow-internee "at a rate of about 400 times an hour with—need it be stated—periods of rest between successive hours.")

2,000 consecutive spins of the coin and 500 successive results of the "urn"-experiment with balls are recorded. The development of the ratio: (number of heads)/(number of spins) is shown in tabular and in graphical form, as are also some derived frequencies, for instance "$m_2/(m_1 + m_2)$, where m_2 denotes the number of times that GREEN was second in the $m_1 + m_2$ experiments in which RED was first" (p. 44). At a later stage a "disc"-experiment is introduced, which is equivalent to spinning a biased coin.

These experiments are used to give to the reader "a vivid impression that if we could take an unlimited succession of increasing values of n and observe a large enough set of values m/n for each value of n, then the successive sets would continue to cluster progressively closer about some fixed value" (p. 24). This fixed value is defined as a mathematical probability and the implications of such definition are examined. The experiments are further used to suggest certain theorems, such as the "addition principle" and the "multiplication principle," and it is shown how these theorems follow from simple assumptions. Throughout the author stresses the distinction between theorems which follow from others without further assumptions and those needing them. If we find any fault with the presentation, it is perhaps the rather disjointed treatment of estimation. Eventually the binomial and the normal distribution are mentioned, the latter without proof. However, its use is adequately demonstrated.

We have found one error on p. 83, where it is (correctly) stated that 99 per cent. of the area under the normal curve lies between $-2,58$ and $+2,58$, but the range $(-1,96; +1,96)$ is given as covering 90 per cent., instead of the correct value 95 per cent.

The author has succeeded in writing a very instructive and easily readable book, and he may rest assured that "students of these pages will never have to reject any ideas given here, no matter how much they may refine them as their knowledge of the subject grows." (p. 6). S. V.

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3.—*The Registrar-General's Statistical Review of England and Wales for the Years* 1938 *and* 1939. Text. London : H.M.S.O., 1947. 9½″ × 6″, xi + 237 pp. 4*s.* 6*d.*

Prior to 1938 the Statistical Review of the Registrar-General for England and Wales was published annually in three parts—Part I (Medical), Part II (Civil) and Part III (Text). The publication of Parts I and II, as separate volumes, has been maintained since that date (publication of the 1945 volumes being expected shortly), but the Text for the years 1938 and 1939 has now been issued as one volume, and it is the intention to issue one further volume for the text of the remaining war years, 1940–45. Amongst the new material included in the 1938–39 volume is a review of data on marital history, collected for the first time in July, 1938, under the provisions of the Population (Statistics) Act of 1938. This review includes an analysis of confidential information on the subject of age of mother for all births, and the duration of marriage for all legitimate births registered since that date.

Deaths.—In England and Wales, 246,731 male and 232,098 female deaths were registered in 1938 and 255,781 and 244,023 respectively in 1939. The resulting crude death rates were 11·6 and 12·1 per 1,000 persons in 1938 and 1939 respectively. The rates standardized for the age and sex constitution of the population were 8·5 per 1,000 in each year, which was 0·5 per 1,000 less than the previous minimum recorded (1935). For both years the standardized death rates from most specific causes of death were lower than the average for the previous five years. A comparison with the mortality rates in the periods 1911–14 and 1931–35 gave the following results:

	England and Wales, average stardandized death rates per 1,000 *persons*		
	1911–14	1931–35	1936–39
London Administrative County . . .	14·5	9·9	9·0
Aggregate of County Boroughs* . . .	15·9	10·7	9·9
,, Urban Districts*	13·0	9·6	8·9
,, Rural Districts*	10·9	8·6	8·1
England and Wales	13·5	9·6	8·9

* Outside Greater London from 1931 onwards.

Over the twenty-five years the London rate declined by 38 per cent., compared with a fall of only 26 per cent. observed in Rural Districts. As a result of the more rapid fall experienced in urban mortality, the percentage excess of the rate for County Boroughs over that for Rural Districts decreased from 46 to 22.

Deaths under one year of age numbered 32,724 in 1938 and 31,190 in the next year; the infant mortality rates were 52·7 and 50·4 per 1,000 live births registered in 1938 and 1939 respectively—the previous minimum was 56·9 in 1935. In each year approximately half the mortality was due to developmental and wasting diseases, of which premature birth accounted for 15·64 and 15·25 deaths per 1,000 registered live births compared with 18·28 in the period 1929–33.

Since 1930 the mortality of young children (ages 1–5) has fallen more rapidly than that of children in the first year of life. The favourable trend of mortality at these ages is demonstrated from life tables, which show that out of 10,000 boys or girls born alive in the years 1910–12 only 8,263 boys or 8,501 girls would have been expected to survive to age five. In 1938 the corresponding figures were 9,224 boys or 9,384 girls, and in 1939 they were 9,299 or 9,346 respectively. The principal causes of death at ages 1–5 were pneumonia, tuberculosis, measles (in 1938 only), violent causes, diphtheria and whooping-cough, which in all accounted for 6,970 out of 10,215 deaths in 1938 and 4,840 (excluding measles) out of 7,294 in 1939.

At school ages (5–15) the death rates were:

	Death rates per 1,000 *persons*	
	1938	1939
Ages 5–10	1·87	1·48
Ages 10–15	1·19	1·03

The principal causes of death at school ages were diphtheria, violent causes, tuberculosis, pneumonia, rheumatic fever and endocarditis and appendicitis in each age group and year. Every cause except violence contributed to the lower rates of the later year.

Between the ages of 15 and 25 the death rates were 2·18 and 2·07 per 1,000 persons living in 1938 and 1939 respectively, non-civilians being excluded from September 3rd, 1939, onwards.

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In recent years the survival of girls to the ages of child bearing has shown great improvement; this factor has considerable effect in the replacement of the population. Thus, out of 3,758,417 girls born alive during the years 1915–24, the number expected to survive to ages 14¾ to 24¾ had they been subjected to the death rates at successive ages of the period 1920–22 would have been 3,230,901. At the date of the National Register (September 29, 1939) the number actually enumerated was as high as 3,289,879. At these young adult ages tuberculosis was responsible for 29 per cent. of the male and 46 per cent. of the female mortality in 1939, while violent causes were responsible for a further 29 per cent. amongst males, but only 7 per cent. amongst females.

Comparing the 1938 mortality rates for each quinquennial age group between 25 and 70 with those of the period 1931–35, for all ages under 50 for males and 60 for females, it is shown that a decrease of 12 per cent. or more had taken place in the mortality rates. At older ages the rates also declined, but by relatively smaller amounts. In 1939 the downward trend was maintained for ages under 50 for males and 40 for females, but above these ages there occurred increases which were sometimes considerable. From 1930 to 1939 a rapid increase in deaths attributed to degenerative heart disease has been continued in the age group 50–65. It is remarked that "a general improvement in death rates from most causes since 1921 has been masked amongst males of these ages by a large and continuing rise in deaths assigned to degenerative heart disease at ages 50–65."

Several points of particular interest arise in the sections devoted to specific causes of death. The standardized death rates from cancer, 1,066 and 961 per million in 1938, and 1,051 and 943 per million in 1939 amongst males and females respectively, when compared with past years suggest that the female rates were tending to decline by 1939, but that this fact was not true of the males. Amongst males the standardized death rates in the years 1931–35 gave an average of 1,045 per million compared with 1,064 in 1936–39. Cancer of the lung in 1939 resulted in a standardized death rate 78 per cent. higher than that of the period 1931–35 amongst males; the corresponding percentage for females was 47. It is possible that this large increase may be due partly to the more frequent use of radiological diagnosis in later years.

In 1938 a special analysis was again made of approximately 1,500 deaths due to maternal causes in relation to the number of previous pregnancies and to whether the birth was single or multiple. It appeared that a higher proportion of deaths occurred (47·1 per cent.) associated with first pregnancies than had been observed in the three previous years—the previous maximum being 43·2 in 1935. The proportion of maternal deaths accompanied by a live birth was 56·6 per cent. for first pregnancies. This proportion decreased with increasing parity to 34·2 per cent. when the mother had experienced four or more previous pregnancies.

Population.—By the same methods of estimation as used previously the mid-year population in 1938 was estimated as 19,792,000 males and 21,423,000 females, and represents a growth of 0·45 per cent. over the previous year. From the National Register and the distribution of births and deaths during the period June, 1938, to September, 1939, the total population as at June 30th, 1939, was calculated as 19,920,000 males and 21,540,000 females.

Marriages.—During 1938 the number of marriages registered was 361,768, the corresponding figure for 1939 being 439,694, which result in marriage rates of 17·6 and 21·2 per 1,000 of the population respectively. The effect of the possible and actual outbreak of war was reflected in the quarterly marriage rates of 1939; the marriages in the third and fourth quarters of that year were respectively 30 and 50 per cent. greater in number than in the corresponding quarters of the previous year.

Births.—The crude live birth rates of 1938 and 1939 were 15·1 and 14·9 per 1,000 of the population respectively, and were not very different from the average of the previous five years (14·7 per 1,000). The number of live births registered was 621,204 in 1938, and 619,352 in 1939, of which respectively 26,379 and 25,942 were illegitimate.

Fertility.—The following table shows the live birth rates per 1,000 women at child-bearing ages :

	England and Wales		
	Legitimate live births per 1,000 *married women aged* 15–49	*Illegitimate live births per* 1,000 *non-married women aged* 15–49	*Total live births per* 1,000 *women aged* 15–49
1938	92·2	5·31	54·4
1939	89·8	5·21	53·6

The number of births among all women over 30 years of age declined from 1938 to 1939, while below that age the number increased; this, coupled with the change in age constitution of the

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population, gave a net result of a fall of 0·8 per 1,000 in the total fertility rates. Considering only legitimate births, the decline in the fertility rate was evident at all age groups of the mother which were examined. An examination of legitimate fertility rates in 1939, by age and duration of marriage, demonstrated, as in 1938, the decrease in fertility which takes place with increasing duration of marriage after the first year. It is stated that "one seventh of all children now born in this country are products of extra-marital conceptions." Thus, in 1939 there were 636,060 confinements, of which 26,570 were illegitimate, and 59,780 occurred within 8½ months of marriage; of the latter over half were born to mothers between the ages of 20 and 25.

In 1939 the average size of the family (obtained from records of previous births at the time of registration of a new birth) was 1·417 children previously born, of which 1·228 were still surviving at the date of the new birth. A table is included in the report which shows for 1939 the average number of previous children distributed according to age of mother and duration of marriage.

E. A. C.

4.—*Income from Independent Professional Practice.* By Milton Friedman and Simon Kuznets. New York: National Bureau of Economic Research. 1945. 9¼" × 6¼". xxxiii + 599 pp. $4.50.

This work comprises a detailed investigation into the level of earnings in five professions in the United States between the years 1929 and 1936, the professions being Medicine, Dentistry, Law, Certified Public Accountancy and Consulting Engineering. The limitation of the study to *independent* professional practice consequently excludes Divinity, Teaching and the Fighting Services, a matter which is rather to be regretted in view of the dramatic contrasts which the inclusion of these professions might have been expected to reveal. Nevertheless, interesting differences are discovered in the five groups studied, while, on the other hand, certain similarities which are established are clearly representative of professional experience as a whole.

By way of background, it is pointed out that of the 50 million persons gainfully occupied in the United States in 1930, 3 million were professional workers. One-sixth of the latter were independent professional practitioners. On the average, professional workers earned between two and three times as much as non-professional workers, while independent practitioners alone earned about four times as much. It is then estimated that the professional worker would have to earn 70 per cent. more than the non-professional worker in order to compensate him for the extra cost of training and the loss of income during the training period. As the extra returns from a professional career are greatly in excess of these extra costs, however, there must be an element of monopoly in professional work. In terms made familiar by Cairnes, professional workers must constitute a non-competing group.

Turning to the five professions chosen for special study, the writers attempt to assess the cost and the monopoly elements in the average incomes of each, and considerable discussion is devoted to the probable nature of the latter. Next, income dispersion is examined and several broad conclusions emerge. Roughly speaking it can be said that the amount of income dispersion varies directly with the level of average income attributed to each group. Consulting Engineering is highest in both respects and Dentistry lowest. Within each profession, however, no matter how wide the income dispersion may be, the relative income position of any individual tends to be stable over a number of years, despite the pronounced life-cycle pattern of earnings in each which constitutes an underlying trend.

Professional incomes are also examined in order to see whether location of practice has any influence on their level. On the whole, it is established that the larger the size of the community in which the practice is situated, the larger the income is likely to be. Between communities of the same size in different regions of the country, however, no significant differences were revealed. The authors suggest that this is evidence of high mobility between regions, and, assuming that similar mobility exists between communities of different sizes, they attempt to account for the higher incomes in the larger communities by suggesting that they reflect either the concentration of abler men in the large cities, or the non-pecuniary advantages of the small communities. In a generally very exhaustive treatment of the subject of income from independent professional practice, this is one of the few points which seem to have received inadequate consideration.

Approaching the subject from another point of view, it is shown that specialists get a higher average reward than general practitioners in both Medicine and Dentistry, while in the other professions, firm members have higher average earnings than individual practitioners of the same age and in communities of the same size. In all professions, of course, independent professional practice tends to be more profitable than salaried employment, though the incomes in the former are more widely dispersed than those in the latter, so that a larger proporiton of independent than of salaried workers receives very low earnings and a larger proportion very high earnings.

A lengthy appendix is devoted to a detailed discussion of the reliability of the Department of

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Commerce samples which represent the principal data used in the study. The questionnaire forms used in the sample survey are also shown, and the material obtained in this and in other ways is worked up and presented in some eighty pages of tabulations, which in themselves form an eloquent testimony to the remarkable industry of the Staff of the National Bureau. T. M. R.

5.—*Reconversion, Modernization and Expansion.* Economic Research Branch, Department of Reconstruction and Supply, Canada. Ottawa, 1946. 105 fols. 14″ × 8″.

The sub-title of this mimeographed official report is "Progress and Programs in selected Canadian Manufacturing Industries, 1945–1947." It gives a summary of progress in 643 major plants formerly engaged in war production. Three alternative situations are presented in the conversion program: a plant may not have needed reconversion; its reconversion may be complete; or its conversion may be in progress. This last case presents further alternatives: progress may or may not be held up by shortage of materials. Both industries and regions are differentiated in respect of the distribution of plants and of employment among these alternatives.

Industries are grouped for summary tables and diagrams into the conventional four classes of non-durable consumers' goods; durable consumers' goods; producers' goods; and basic materials. But the industries within each of the groups are far from homogeneous in respect of reconversion problems. Producers' goods industries varied in the proportion of their plants not requiring reconversion all the way from 100 per cent. in iron and steel to 31 per cent. in electrical apparatus; non-durable consumer goods industries varied from 92·5 per cent. in food and tobacco to 47·0 per cent. in footwear. Need to reconvert depends on how far normal products are as useful in war as in peacetime, and a consumer's non-durable goods, like food, is in much the same position as a basic material or producers' goods like iron and steel.

For all industries covered, reconversion was not required for 62·5 per cent. of plants, and reconversion was complete by February, 1946, for 19 per cent. The remaining 18·5 per cent. of plants were not fully reconverted mainly because of shortages—applying to 11 per cent. of all plants. Least progress is reported to have been made in the non-durable consumers' goods group. But here again the grouping adopted cloaks big differences; for of the four industries in this particular group, two have reconverted unusually fast. Primary textiles had only 8 per cent. of its plants unreconverted, food and tobacco only 5 per cent. The real hold-up was in clothing and footwear.

Particularly interesting to the economist is the information given on modernization and expansion. It appears that a greater proportion of the larger plants had plans both for modernization and expansion (*i.e.*, additional investment) than the smaller plants, but the expected increase in the employment of labour was relatively greater for the smaller plants. The report suggests tentatively that the investment programmes of the larger plants are of a labour-saving nature to a greater degree than is the case among smaller plants.

The location of expansion and modernization is also measured, since progress is reported separately for five regions of Canada and nine major industrial centres. Comparing regions, it would appear that "to him that hath shall be given," for the two regions employing most workers on May 1, 1946, Quebec and Ontario, expect to have the largest proportional increases in employment resulting from modernization and expansion.

In conclusion, one can only wish that some similar investigation were published in Great Britain, and be grateful that the Canadian Government has pointed the way. P. S. F.

6.—*Bretton Woods, for Better or Worse.* By R. G. Hawtrey. London: Longmans Green, 1946. 7½″ × 5½″. vii + 142 pp. 7*s.* 6*d.*

Any exchange regime which envisages even the provisional stabilization of exchange rates with the aid of internationally acceptable reserves must partake of some features of the gold standard. Hence, nobody could reasonably cavil at the suggestion that Bretton Woods represents a return to the gold standard with a difference. Controversy arises when it comes to assessing how fundamental the difference is on paper, or is likely to prove in practice; and—leaving aside the opposition of the bilateralists—those who dislike the gold standard will the more approve of Bretton Woods the higher they rate the dissimilarities of the two systems, and conversely.

British opinion is undoubtedly resolved that our economic life must never again be subjected to the tyranny of a rigid parity for sterling, that monetary policy must henceforth seek to achieve objectives quite different from the maintenance of a fixed exchange rate or the protection of an exchange reserve. Lord Keynes therefore made the best bid to commend Bretton Woods to this

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country when he argued that its greater flexibility, and in particular the provision for adjustments in parities, would permit that revolutionary departure in monetary policy. Mr. Hawtrey has many interesting and informed technical criticisms of the new system, but essentially he is questioning the practical extent of that supposed flexibility.

In other words, he is arguing fundamentally that the new system approximates more to the gold standard than British opinion would approve, and his basic criticisms are those which he would level at the gold standard itself: that fixed exchange rates tend to transmit inflationary or deflationary movements throughout the whole system, producing instability and the trade cycle. In a general deflation, he urges, no one country will be able to devalue, because it would be accused of competitive depreciation; in a general expansionary movement no country will be able to appreciate its currency because this would be opposed by its own exporters.

Everything depends, of course, not so much on the new machinery as on how it is worked. Supporters of Bretton Woods would undoubtedly reply that a country could not, on the modern monetary philosophy, be accused of *competitive* depreciation if its export industries were suffering from mass unemployment ; and they would dispose of Mr. Hawtrey's second contention by pointing to the examples already set by Canada and Sweden.

But is there not a deeper contradiction in Mr. Hawtrey's approach? His fear that the new system will produce as much instability as the gold standard does not derive ultimately from criticisms of machinery, but from his belief that central banks remain untouched by the recent general upheaval in monetary thought, are wedded to the old philosophy, and therefore would never check an inflationary movement unless this threatened their exchange reserves. If that is the case, however, could one really expect any greater general stability under the regime Mr. Hawtrey himself favours: that is, unpegged and fluctuating exchange rates, determined by the day-to-day intervention in the market of exchange stabilization funds?—for the policies of such funds must equally be dominated by the philosophies of central banks and Treasuries. If, on the other hand, one believes that these authorities would now aim at the stabilization of their national economies (which probably means, as Mr. Hawtrey argues, the stabilization of factor costs), then supporters of Bretton Woods would not agree that there is anything in the new system to prevent this, provided that the International Monetary Fund also shares the new philosophy—and on that point the completely Keynesian interpretation of its functions given by M. Gutt is certainly most reassuring.

Finally, not everybody would accept the implication of Mr. Hawtrey's title that we are now wedded indissolubly to the new system and must accept the consequences come what may. In Mr. Hawtrey's own system of thought the villains of the piece have always been the central bankers (with the shining exception, of course, of the late and seemingly infallible Benjamin Strong). The trouble, he holds, was caused by the stubborn determination of central banks to defend their exchange parities; legislatures have always been ready to pass amending legislation and go off the gold standard when circumstances so required. That being so, there is no reason why they should not be equally willing, should circumstances require, to approve of their countries walking out of Bretton Woods, as any member is free to do.

One only hopes that the whole discussion is not academic. By comparison with some of the dangers now looming over the horizon, even if the Bretton Woods marriage should turn out as badly as Mr. Hawtrey fears our troubles would all be little ones. W. M. D.

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STATISTICAL NOTES

(1) British Official Statistics

The table below shows, in summary form, movements in the oversea trade of the United Kingdom in the second quarter of 1947, with comparable figures for the two preceding quarters and for the years 1938 and 1946.

Although exports have recovered fairly rapidly from the immediate effects of the fuel crisis, the total value recorded in the quarter (£265·4 million, compared with £249·7 million in the first three months of the year) was still slightly below the peak figure recorded in the fourth quarter of 1946. Compared with the first three months of the year the value of retained imports, however, showed an increase of nearly one-third, to £438·4 million. The adverse balance shown by the official statistics thus increased between the two quarters by £77 million and amounted to £173 million.

Total imports in the quarter were valued at £456·2 million, compared with £363·8 million in the first three months. Average values of imports increased by about 11 per cent. to 168 per cent. above those in 1938, and in terms of volume imports were at 76 per cent. of the 1938 level compared with 66 per cent. in the preceding three months. Re-exports (£17·8 million—56 per cent. of the 1938 volume) were rather lower than in the first quarter, a reduction of £2·0 million for rubber being only partly offset by heavy re-exports of raw cotton.

£ million

	1938	1946	1946	1947	
	Quarterly average		Fourth quarter	First quarter	Second quarter
Retained Imports, c.i.f.					
Food, drink and tobacco	104·5	156·3	173·2	182·5	212·4
Raw materials and articles mainly unmanufactured	54·5	89·1	104·3	89·8	128·3
Articles wholly or mainly manufactured	53·8	59·5	72·3	67·2	92·5
Other articles	1·7	6·9	6·4	6·1	5·2
Total	214·5	311·8	356·2	345·6	438·4
United Kingdom Exports, f.o.b.					
Food, drink and tobacco	9·0	15·9	14·1	12·9	14·9
Raw materials and articles mainly unmanufactured	14·2	8·2	9·1	10·0	9·1
Articles wholly or mainly manufactured					
Metal goods	43·9	100·6	123·0	115·0	127·4
Textiles	25·3	46·6	54·0	52·7	52·8
Other manufactures	22·1	49·4	57·9	50·6	52·3
Other articles	3·2	7·2	8·1	8·5	8·8
Total	117·7	227·9	266·2	249·7	265·4
Exports of Imported Merchandise, f.o.b. ..	15·4	12·6	13·9	18·2	17·8

Retained imports of both raw materials and manufactured articles increased by about two-fifths between the first two quarters, but those of food, drink and tobacco showed a smaller increase —one-sixth. The increase for foodstuffs was due essentially to larger supplies of grain and flour (£43 million) and of miscellaneous foods (£47·5 million). Supplies of meat (81 per cent. of those

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in 1938) were also higher, but those of dairy produce and of beverages were each lower by about a tenth. Imports of tobacco fell by more than a quarter, most of the United States 1946 crop having already been shipped to this country. Among the raw materials the most important increase was that of £16·5 million for oils, oilseeds, etc., which brought the volume index for this group to 111 (1938 = 100)—the highest level since 1940. Timber supplies showed more than the normal seasonal expansion to more than double the level of the first three months (though by volume imports were still less than three-fifths of those in 1938); retained imports of raw cotton and raw wool increased to 89 per cent. and 97 per cent. respectively of the pre-war volume. The only important reductions were for hides and skins and for rubber; re-exports of rubber were still comparatively high and, with heavily reduced imports, the volume of retained imports for this group was only one-fifth of that in 1938. For manufactured articles almost every group showed a substantial increase over the preceding quarter, the only important exception being manufactured oils, fats and resins (essentially petroleum), imports of which were the lowest since 1939.

Allowing for the rise in prices since 1938, the volume of United Kingdom exports in the second quarter is estimated at 102 per cent. of 1938 compared with 101 for the preceding three months and 111 for the last quarter of 1946. N.A.A.F.I. supplies and U.N.R.R.A. shipments have declined steadily in importance over the last year, but still accounted for over 2 per cent. of the total, so that commercial exports were at about the same level as in 1938.

Exports of food, drink and tobacco (£14·9 million) were £2 million higher than in the first quarter—mainly as a result of heavier shipments of sugar (nearly double those in the first quarter). For raw materials there was a reduction of £0·9 million and the volume was only one quarter of that in 1938; coal exports (only 2 per cent. of those in 1938) were the smallest since the coal stoppage in 1926.

The volume of exports of manufactured articles was 16 per cent. higher than in 1938; although slightly above the first quarter level the volume was still 8 per cent. below that in the fourth quarter of last year, machinery and iron and steel being the only important groups for which the fourth quarter level was exceeded. The metal groups taken together had a volume index of 148 (higher than in any other quarter except the fourth quarter of 1946); each of the groups was above the 1938 volume, the increases ranging from 6 per cent. for iron and steel to about three-quarters for vehicles and for cutlery, hardware, etc. The tonnage of machinery exported has been practically unchanged in the last three-quarters at about 43 per cent. above the 1938 level, the most important increases compared with the pre-war year being those for agricultural machinery (nearly three times as high) and machine tools (about doubled). Exports of motor cars reached a new record level in the quarter and were two and a half times the 1938 average, while shipments of other road vehicles and of railway rolling stock were also well above the pre-war averages.

The volume of textiles exports as a whole was 68 per cent. of 1938—the lowest since the second quarter of last year; all groups except cotton (which remained at about two-fifths of the pre-war volume) shared in the reduction compared with the preceding quarter. Shipments of woollen and worsted and of miscellaneous textiles each fell to nearly one-quarter below the 1938 level, but the volume in that year was still exceeded by two-fifths for both apparel and silk and rayon manufactures.

For all other manufactures the volume of exports (108 per cent. of 1938) was the lowest since the first quarter of 1946, the two largest groups in this section—chemicals, drugs, etc., and miscellaneous manufactures—each being between one-fifth and one-sixth below the peak level of the fourth quarter of last year.

(2) Other Statistics

The Food and Agriculture Organization of the United Nations has issued an interesting review of the *World Wheat Situation* (F.A.O. Commodity Series, No. 1, March, 1947) covering a general historical and statistical summary of the position as it developed up to 1939, the changes brought about by the war and some observations on possible future trends. The background of what has come to be called the wheat problem lies in the disequilibrium between supply and demand

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which arose after the first World War, primarily from a great increase in production in the countries of the New World combined, after the American depression in 1930, with national policies in nearly all countries aiming at the protection of their own producers against falling prices. Thus, a recurrent feature of the pre-war years was the accumulation of unmanageable surpluses in the exporting countries, mitigated or relieved from time to time by poor harvests. The war, though it has altered the position, has not changed its fundamental characteristics. For the moment the export surplus of the major exporting countries is insufficient to offset the decrease in production elsewhere, though the effective demand is dominated by financial considerations, that is not by needs but by the available supply of foreign exchange. Europe, however, will certainly try to restore her agricultural production as quickly as possible. Most European governments have to husband their foreign exchange resources carefully, and from their point of view the sooner they can cease spending money on emergency food imports, the sooner they will be able to purchase equipment and raw materials for the rehabilitation of their industries. Thus their financial position obliges them to become as self-supporting as possible in all things they can reasonably produce, and of these wheat takes a prominent place. It may well be, the Report suggests, that self-sufficiency in wheat might be pushed even further than it was in the 1930's. The same argument applies to India and Eastern countries generally, so that the overall tendency is likely to be towards a shrinking import demand. If during this transition period the four major exporting countries (U.S.A., Canada, Argentina and Australia) maintain the present level of output, then, apart from bad harvests, burdensome surpluses are bound to accumulate as they did before the war, and the same problem is likely to recur, viz. how to secure an adjustment between supply and demand without serious injury to agricultural production. and without disastrous consequences to the agricultural populations of many countries. The Report supports in general arguments in favour of some form of international wheat agreement (which has been under discussion for years), but remarks that it must not be supposed that such an agreement, though helpful, would by itself solve the problem which, in its final analysis, involves wider and more comprehensive tasks. One is to establish the economy of the war-devastated countries upon a firm basis, so that with adequate export markets they can pay their way. The other is to build up the economies of the less developed countries so that they can achieve high living standards partly through increased output and partly through developing exports to exchange for the things they need to import.

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CURRENT NOTES

The Council of the Royal Institute of International Affairs has appointed Mr. R. G. Hawtrey, C.B., the Price Professor of International Economics at Chatham House, in succession to Dr. Allan B. Fisher, who resigned last year to take up a post on the research staff of the International Monetary Fund. Mr. Hawtrey will work in close association with Professor Arnold J. Toynbee, the Director of Studies at Chatham House.

The Research Chair in International Economics was established in 1936 by gift from Sir Henry Price, a member of the Council of the Institute. It is the senior post in Economics at Chatham House, and a position of growing importance in view of the emphasis which the Council places on the economic aspects of the studies undertaken at the Institute. The Research professors are appointed by the Council on the recommendation of an Advisory Board constituted in connection with each Chair. The Board which advised the Council on the appointment of the Price Professor was as follows:

Viscount Astor, Sir Oliver Franks, John Coatman, C.I.E., Sir Henry Clay, Professor D. H. Robertson, C.M.G., F.B.A., Professor Lionel Robbins, Professor Lindley M. Fraser, Professor J. G. Smith, together with the following experts in the subject of the Chair: H. C. B. Mynors, J. E. Meade, C.B.

THE French Government, awake to the necessity of better co-ordination of the statistical and economic activities of the several ministries, have set up, within the Ministère de l'Économie Nationale, an Institut National de la Statistique et des Études Économiques. The statistical and economic sections will have their separate and complementary functions, and by giving a true picture of conditions and a reasoned view of prospects, will provide a basis for governmental action. The Institute will henceforward be responsible for the *Bulletin de l'Évolution Hebdomadaire Économique*, for the *Bulletin mensuel de la Statistique Générale de la France*, and for two new monthly publications entitled *Études Économiques et Conjoncture*, the one relating to the Union Française, the other to the other parts of the world. By the courtesy of M. A. Piatier, Director of the section responsible for these studies, the Society has received copies of the *Union Française*, issue Nos. 1–2 (August and September, 1946), and of the *Mondiale*, issue No. 4 (September, 1946). These periodicals replace the former *Point Économique* (of very limited circulation) and the monthly review issued by the Service des Économies Étrangères. The lay out of the first of these consists of a preliminary general survey and future prospects, and two sets of articles. Part I, headed "Évolution récente de l'économie française," gives statistics, tables and graphs, with notes and explanatory commentary, showing the position over the ten preceding months (in this case January, 1945–July, 1946) for each of the main factors of the national economy, namely: Population and health; wages, prices and consumption; credit and public finance; foreign trade; agriculture and food supply; industry. The commentary throughout is both enlightening and well written, enabling the reader to appreciate the difficulties confronting the French in their rehabilitation—difficulties in the main, like our own, of shortage of labour, fuel and, consequently, of production with the chain of disequilibria which follow. Part V of the volume, *Études d'Actualité*, comprises special studies, the subject matter of which will vary according to topical interest. In this number there are four such studies, dealing respectively with the part played by imports in the food supply; the development of the acreage of wheat cultivation since the war; the cost of agricultural reconstruction in France and the resulting yield; indices of industrial production. In the cover is a pocket containing loose tables and graphs completed to July, 1946, with space for continuation as figures are published. Those included in the first number relate to coal production and import and the course of official salaries.

The volume relating to the world outside France follows much the same lines. After a general view of the world situation, with especial regard to the raw material position, come analyses of the economic situation in selected countries (in this issue Sweden, Great Britain, the United States, and Brazil), with an article on inflation in the Middle East. The section Études d'Actualités here consists of three articles: an analysis of the cost of distribution in the United States; the fourth five-year plan and Soviet industry; and the raw silk market in the Far East.

In Mr. Yule's article on Cumulative Sampling (*Journal*, vol. cix, p. 44) he stated in a footnote on p. 45 that he hoped to publish later his evidence for the view that the Teutonic, not the Italian, family of texts of the *De Imitatione Christi* represents the more primitive form. This has now

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appeared in a paper entitled "Puyol's Classes A and B of Texts of the *De Imitatione Christi*: a critical examination of his evidence and conclusions" (*Recherches de Théologie ancienne et médiévale, Louvain*, tome xiv, Janvier, 1947). A copy of the reprint has been presented to the Society's Library and can be borrowed by any Fellow who is interested.

The following extract from *The Financial Times* of Monday, June 23, 1947, may interest readers of the *Journal* :

"Ministerial Statistics: I am glad the Royal Statistical Society has decided to institute examinations for certificates. A committee has even drawn up specimen examination papers. The idea might be extended. Why not, for example, a test for Cabinet Ministers, in view of the dominant part statistics play in politics to-day (and the evident need of some Ministers of it)? Here are some suggestions for a test paper:

MINISTERS' EXAMINATION PAPER.

(*Candidates must answer all three questions.*)

(1) Prove the following by plausible statistical analysis :

(*a*) That more is produced in five days than five and a half.
(*b*) That the right way to publish weekly coal figures is monthly.
(*c*) That it is better to plough back profits than dissipate them in bonus shares.
(*d*) That past years' Budget votes make this year's surplus.
(*e*) That Railway stockholders prefer 2½ per cent. to 4 per cent.
(*f*) That E.P.T. is "revenue" when received and "capital" when refunded.
(*g*) That convertibility will make sterling a scarce currency.
(*h*) That Stock Exchange prices are always right.
(*i*) That fares should be raised because the Treasury drew £183 millions from war-time railway surpluses.
(*j*) That import "cuts" mean higher exports.

(2) Construct an index number which will (*a*) make it possible to ascertain the rise in the cost of living since 1939, and (*b*) mask the effect of future changes in Government subsidy policy.

(3) Write an essay showing how you would demonstrate that the price of imported coal was, variously, (i) £5 a ton, (ii) £8 a ton and (iii) "unpredictable," before—

(*a*) The Cabinet,
(*b*) The Commons at question time,
(*c*) A miners' mass meeting, and
(*d*) The Council of the Royal Statistical Society."

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OBITUARY

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IRVING FISHER

Irving Fisher, who died on April 29, 1947, at the age of 80, has left a name familiar to both economists and statisticians. His academic training was that of a mathematician, and he was a lecturer in mathematics at Yale when at the age of 25 he turned to economics.

In 1896 he produced a monograph on *Appreciation and Interest*, showing the relation between the rate of interest and changes in the purchasing power of the money unit. The principle that appreciation or depreciation of the value of money should, and to some extent does, lower or raise the rate of interest was not altogether new. But he elaborated it and gave it new emphasis, so that ever since it has been associated with his name.

Fisher became Assistant Professor of Political Economy at Yale in 1895 and Professor in 1898. His interest in the purchasing power of money continued. With a mathematician's desire for precision and generality, he looked for a revised quantity theory of money, and in his *Purchasing Power of Money* (1911) he produced his well-known equation of exchange. In this also he had been anticipated, but his new and thorough work, both theoretical and statistical, resulted in the formula being recognized as peculiarly his.

Since 1905 he had begun to take up a cause which came to be the dominating interest of his life, the stabilization of the purchasing power of money. In the *Purchasing Power of Money* he produced a constructive plan, for which he has since become famous, for adjusting the gold equivalent of the money unit at short regular intervals, so as to compensate changes in the purchasing power of gold as recorded by an index number of prices. A paper on the plan which Fisher read at the International Congress of Chambers of Commerce at Boston in 1912 attracted widespread interest and controversy.

After the first World War he initiated a Stable Money Movement, and a Stable Money Association was founded in 1926.

In *Stable Money* (1934) Fisher gave interesting particulars of the movement and of the part taken in it by others as well as by himself.

"One of the greatest obstacles standing in the way of stabilization," he wrote, "was a prevalent idea that index numbers were unreliable. . . . In order to do my bit toward solving this problem I wrote *The Making of Index Numbers*." In this work (1922) once again the desire for generality and precision is paramount; it was a solid and permanent contribution to statistical science.

Fisher's early work, *Appreciation and Interest*, had been expanded into a book, *The Rate of Interest* (1907). When it was out of print, he long postponed the preparation of a new edition. He wanted to revise the presentation and to rewrite portions which had not been understood. Eventually (1930) he produced what he described as a new book, *The Theory of Interest*. This is a thorough treatment of the fundamentals of the subject. In the preface Fisher remarked: "I have, for the first time, in a book on pure economic theory, introduced mathematics into the text instead of relegating it entirely to appendices. This is done in view of the increasing use of mathematics and the increasing numbers of students equipped to read mathematical economics and statistics."

In *The Theory of Interest*, as in the previous version, *The Rate of Interest*, the early work on *Appreciation and Interest* survived, and provided material for two of its 21 chapters, and the relationship existing between prices and interest rates was "tested by new and rigorous statistical methods of analysis."

The works mentioned are only a selection of those which were produced by Fisher in the course of a long and fruitful life, and which have gained him a secure position among those who have contributed to the advancement of economic science.

R. G. H.

MICHEL HUBER

By the death on April 29, 1947, at the age of 72, of Monsieur Michel Huber, the science of statistics loses a leading exponent. Michel Huber began his career as a statistician at the age of 24, when he was chosen by Lucien March as one of his collaborators in the task of reorganizing la Statistique Générale de la France in 1900. He remained with this department for 36 years,

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becoming Director on the retirement of L. March in 1920. He played a large part in improving French statistics, particularly demographic statistics, was largely responsible for organizing the quinquennial censuses of population from 1901 to 1936, and was editor of the *Bulletin de la Statistique Générale de la France* from its foundation in 1912 till 1936. He was a member of the Conseil Supérieur de Statistique, Secretary-General of the Commission central du coût de la vie and many other bodies. He was appointed Officier de la Légion d'honneur in 1920, and was twice awarded the Montyon prize of the Académie des Sciences for his contributions to statistics. In 1937 he was made an Honorary Fellow of the Royal Statistical Society, and enjoyed the honorary membership of many other statistical societies throughout the world. His work as a government official did not prevent him from playing a large part in the teaching of statistics in France, and in the development of comparable international statistics. He was one of the founders in 1922 of the Institut de Statistique of the University of Paris where he held the posts of Secretary-General, Director of Studies and Professor, and many of France's present statisticians owe their knowledge and inspiration to his teaching. He held the chair of Démographie et Statistique sanitaire till 1933, and on the death of L. March, that of Statistique appliquée aux affaires, which he held until 1944. The substance of his lectures on these subjects, revised and completed, formed the chief occupations of his leisure after retirement, and the result is in 11 volumes of more than 1,700 pages of which 6 are devoted to demography and 5 to statistics applied to business (i.e. economic statistics, price statistics, production, consumption, business forecasting, etc.). Of these, 10 have been published; the proofs of the last volume were in process of correction by the author at the time of his death.

These two activities—government statistician and professor—were not, however, sufficient for his active and creative mind, and he is perhaps best known among statisticians of other countries for his work in the sphere of international statistics. Few devoted themselves with such energy and devotion to the work of bodies such as the International Statistical Institute, the League of Nations, and the International Labour Office. He became Vice-President of the Institute in 1931, and in 1933 editor-in-chief of the scientific part of the *Revue trimestrielle de l'Institut International de Statistique*. He attended every session of the Institut from 1911 to the last in 1938, and was chairman or *rapporteur* of one or more Sections at most of the sessions. He was a member of the Committee of Statistical Experts of the League of Nations from its foundation in 1931, and elected president in 1937. He was also a member of the Committee of Expert Statisticians of the International Labour Office and its president for many years.

Statistical science loses in him a devoted servant. He gave to it during almost half a century all his energy. In addition to his wide and varied competence he had a lucid intelligence, a great power of concentration, a clarity of expression, and the true scientific spirit. He was an ideal chairman or *rapporteur*. Those who have sat round the table with him would marvel at the ease and rapidity with which he would draft, in clear, concise and perfect French, a text of a resolution or a paragraph of a report in which no word was superfluous and no phrase was ambiguous. His profound knowledge of statistics, his clear brain and his ready and apt phraseology made him the perfect member of gatherings of international statisticians whatever the subject discussed. First impressions were apt to be those of a cold, reserved character under a rather gruff exterior, but those who got to know him thoroughly realized that these characteristics were due to his habit of concentration, and accentuated by the extremely defective eyesight from which he suffered all his life. Closer acquaintance revealed a man of sensitive feelings, of pleasant disposition and kindly nature. Unambitious, never seeking position for himself, with no axe to grind, he was an outstanding example of the true scientific thinker. Honesty, conscientiousness, precision marked his work and made him an ideal civil servant, a perfect professor and a true international statistician.

During the war he remained most of the time in Paris, and showed his fund of kindness and generosity by undertaking frequent, long and arduous journeys to visit the writer in the camp in which he was interned during the German occupation, by keeping him supplied regularly with the *Journal de la Société de Statistique de Paris* and other statistical publications, and by even bringing him food from his scanty resources. He lived most of his life in his small bachelor flat in the Quartier Latin near his beloved Institut de Statistique at the Sorbonne, to which friends were rarely invited. When the writer visited him there in 1944 and 1945, he was obviously suffering from the effects of the occupation and from the knowledge of what some of his friends had endured. Shortly after he had a serious illness, from which he apparently recovered. His one wish in those days was to be active again, and fit enough to attend the Washington session of the International Statistical Institute to which he was so much attached. His death creates a void in the ranks of statisticians, not only in his native country but in the world, which it will be difficult to fill.

J. W. N.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

The Banker—

January 1947—The crisis of the franc: *René Fleury*. The Australian pound: *A Special Correspondent*. Credit expansion in New Zealand: *A Special Correspondent*. Canada's economic transition: *H. Dargan Roberts*.

February 1947—Bankers and cheap money. A rational plan for wages: *E. Victor Morgan*. The cost of Germany. Indian finances in transition: *H. C. G. Slater*.

Biometrika—

January 1947—The variance of the overlap of geometrical figures with reference to a bombing problem: *F. Garwood*. A study of a first dynasty series of Egyptian skulls from Sakkara and of an eleventh dynasty series from Thebes: *A. Batrawi* and *G. M. Morant*. The generalization of "Student's" problem when several different population variances are involved: *B. L. Welch*. The distribution of Kendall's r coefficient of rank correlation in rankings containing ties: *G. P. Sillitto*. The use of range in place of standard deviation in the t test: *E. Lord*. The frequency distribution of $\sqrt{b_1}$ for samples of all sizes drawn at random from a normal population: *R. C. Geary*. On the computation of universal moments of tests of statistical normality derived from samples drawn at random from a normal universe. Applications to the calculation of the seventh moment of b_2: *R. C. Geary* and *J. P. G. Worlledge*. The asymptotical distribution of range in samples from a normal population: *G. Elfving*. Limits of the ratio of mean range to standard deviation: *R. L. Plackett*. Significance tests for 2×2 tables: *G. A. Barnard*. The choice of statistical tests illustrated on the interpretation of data classed in a 2×2 table: *E. S. Pearson*. 2×2 tables. A note on E. S. Pearson's paper: *G. A. Barnard*. The cumulants of the z and of the logarithmic χ^2 and t distributions: *J. Wishart*. The meaning of a significance level: *J. Wishart*.

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Vol. XIII, No. 33—A model of general economic equilibrium: *J. v. Neumann*. A note on J. v. Neumann's article: *D. G. Champernowne*. The scope and method of economics: *O. Lange*. The German war economy: *N. Kaldor*.

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Economic Record—

December 1946—Travelling to work: *D. Cochrane.* The Australian social services contribution and income tax acts, 1946: *H. S. Carslaw.* The nationalization of the Bank of New Zealand: *C. G. F. Simkin.* An index of engineering unemployment, 1852–1943: *N. G. Butlin.*

INDIA—

Sankhyā—

November 1946—On some analogues of the amount of information and their use in statistical estimation: *A. Bhattacharyya.* Multivariate analysis of variance: the sampling distribution of the numerically largest of the p-statistics on the non-null hypothesis: *S. N. Roy.* A note on multivariate analysis of variance when the number of variates is greater than the number of linear hypotheses: *S. N. Roy.* On the average power of test criteria: *H. K. Nandi.* A note on the expected discrepancy in the estimation (by double sampling) of a variate in terms of concomitant variate when there exists non-linear regression between the two variates: *Mrs. C. Bose* and *A. K. Gayen.* A note on the agrarian economy in Tamluk subdivision during 1939–44: *A. Ghosh* and *S. Gupta.* Analysis of data of physical measurements: *J. S. Chowhan* and *S. J. Aiyar.*

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South African Journal of Economics—

September 1946—The problem of imperial preference: *G. S. H. Rossouw.* Economists and government: *G. W. G. Browne.* Economic historians and their colleagues: *H. M. Robertson.* Consumption, investment and war expenditure in relation to the national income: *Prof. S. Herbert Frankel.*

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American Academy of Political and Social Science, Annals—

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January 1947—Social implications of modern science. (Whole number.)

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January 1947—Anciens et nouveaux indices de corrélation. Leur application au calcul des retards économiques: *Maurice Fréchet.* Effects of increased productivity upon the ratio of urban to rural population: *Herbert A. Simon.* Note on the Doolittle solution: *Nancy Bruner.* Accuracy in the Doolittle solution: *Dickson H. Leavens.* Technological change and aggregation: *Kenneth May.*

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Winter 1946—Financing the International Bank: *Henry C. Wallich.* Small business: a community problem: *Charles C. Abbott.* Crisis in the domestic shipping industry: *Paul F. Lawler.*

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November 1946—Keynes' contribution to economics—four views: *Messrs. Harrod, Hansen, Haberler* and *Schumpeter.* Five views on the consumption function: *Miss Brady* and *Messrs. Katona, Likert, Bean, Friend* and *Bennion.* Replacement in the shipping industry: *Johan Einarsen.* Employment during the transition period, in prospect and retrospect: *Eric Schiff.* Lending operations of the international monetary fund: *Alice Bourneuf.*

February 1947—Factors governing the length of inventory cycles: *Lloyd A. Metzler.* The American economy in transition: *Messrs. Hitch, Livingston, George and Landry, Smithies* and *Hubbard.* Sales taxation and the mints plan: *M. Bronfenbrenner.* Appraisal of methods for estimating the size distribution of a given aggregate income: *Eugene Clark* and *Leo Fishman.*

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December 1946—The national income of Soviet Russia: *Julius Wyler.*

BELGIUM—

Bulletin de l'Institut de Recherches Economiques et Sociales—

January 1947—L'adaptation des comptabilités à la dépréciation monétaire et à la hausse des prix: *René Sterkendries.* La fonction logistique et la description des phénomènes de développement économiques et sociaux: *Paul-Emile Corbiau.* Base mathématique de la théorie de l'Intérêt: *Albert Beumier.*

EGYPT—

L'Egypte Contemporaine—

May–December 1946—The Egyptian national life tables: *Ahmad Gad Abdel Rahman.* Seasonality of the Egyptian export trade: *Mohamed Hosny el Said.*

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FRANCE—

Population—

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REVENUE OF THE UNITED KINGDOM

Net Produce in Quarters of 1946, *and in Financial Years ended March* 31, 1946–47, 1945–46, 1944–45, 1943–44

(000's omitted)

QUARTERS ended	March 31, 1946	June 30, 1946	Sept. 30, 1946	Dec. 31, 1946	Total for Calendar Year 1946
	£	£	£	£	£
Customs	144,862	139,879	153,386	162,655	600,782
Excise	138,100	137,000	141,800	145,600	562,500
Stamps and Estate etc. Duties	39,593	45,695	41,945	48,238	175,471
Other Inland Revenue Duties	556	118	40	10	724
Post Office	29,400	30,200	31,450	34,550	125,600
Wireless Licences	1,780	1,110	1,960	3,310	8,160
National Defence Contributions	9,577	7,364	9,241	9,007	35,189
Excess Profits Tax	96,922	123,275	146,167	128,982	495,346
	460,790	484,641	525,989	532,352	2,003,772
Income Tax and Surtax	774,391	211,889	217,535	131,226	1,335,041
	1,235,181	696,530	743,524	663,578	3,338,813
Motor Vehicles Duties	31,308	5,141	4,553	3,566	44,568
Crown Lands	240	190	260	230	920
Interest on Sundry Loans	3,659	3,519	3,974	14,718	25,870
Sale of Surplus War Stores	—	545	34,142	67,133	101,820
Surplus Receipts from Certain Trading Services	—	—	—	40,000	40,000
Miscellaneous Receipts	13,765	4,262	12,895	12,786	43,708
	1,284,153	710,187	799,348	802,011	3,595,699

YEARS ended March 31	1946–47	1945–46	1946–47 (compared with 1945–46		Corresponding Years	
			Increase	Decrease	1944–45	1943–44
	£	£	£	£	£	£
Customs	620,741	569,842	50,899	—	579,352	560,832
Excise	563,500	540,800	22,700	—	496,900	482,200
Stamps and Estate etc. Duties ...	186,382	145,400	40,982	—	127,898	117,206
Other Inland Revenue Duties	724	712	12	—	779	968
Post Office	131,000	115,500	15,500	—	116,600	111,000
Wireless Licences	9,940	5,180	4,760	—	4,820	4,820
National Defence Contributions ...	32,107	35,485	—	3,378	33,304	33,304
Excess Profits Tax	475,913	432,130	43,783	—	477,134	466,668
	2,020,307	1,845,049	178,636	3,378	1,836,787	1,777,070
Income Tax and Surtax...	1,231,975	1,430,415	—	198,440	1,390,374	1,259,625
	3,252,282	3,275,464	178,636	201,818	3,227,161	3,036,695
Motor Vehicles Duties	49,456	43,172	6,284	—	28,965	27,294
Crown Lands	920	960	—	40	980	1,060
Interest on Sundry Loans	26,779	11,046	15,733	—	7,520	6,455
Surplus Receipts from Certain Trading Services	59,000	—	59,000	—	—	—
Sale of Surplus War Stores	155,996	—	155,996	—	—	—
Miscellaneous Receipts	78,312	70,561	7,751	—	90,037	77,876
	3,622,745	3,401,203	423,400	201,858	3,354,663	3,149,380
			NET INCR. £221,542			

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BANK OF ENGLAND

Pursuant to the Act 7th and 8th Victoria, cap. 32 (1844)

(000's omitted)

1	2	3	4	5	6	7	8
		Issue Department				Collateral Columns	
Liabilities		Assets					
Notes Issued	Dates (Wednesdays)	Govt. Debt (11,015) and Govt. Securities	Other Securities	Gold Coin and Bullion†	Silver Coin‡	Notes in Hands of Public	Minimum Discount Rate
£		£	£	£	£	£	%
1,400,248	Jan. 2	1,399,334	660	248	6	1,374,768	
1,400,248	,, 9	1,399,343	648	248	9	1,358,847	
1,400,248	,, 16	1,399,278	715	248	7	1,344,738	2
1,400,248	,, 23	1,399,298	693	248	9	1,334,719	
1,400,248	,, 30	1,399,307	682	248	11	1,331,400	(26.10.39)
1,400,248	Feb. 6	1,399,206	786	248	8	1,333,802	
1,400,248	,, 13	1,399,230	762	248	8	1,328,716	
1,400,248	,, 20	1,399,203	787	248	10	1,322,584	
1,400,248	,, 27	1,399,206	784	248	10	1,323,114	
1,400,248	Mar. 6*	1,399,281	710	248	9	1,324,001	
1,400,248	,, 13	1,399,246	746	248	8	1,326,276	
1,400,248	,, 20	1,399,274	716	248	10	1,325,497	
1,400,248	,, 27	1,399,193	800	248	7	1,328,321	
1,400,248	April 3	1,399,207	786	248	7	1,333,892	
1,400,248	,, 10	1,399,124	869	248	7	1,338,754	
1,400,248	,, 17	1,399,090	904	248	6	1,346,218	
1,400,248	,, 24	1,399,132	862	248	6	1,348,255	
1,400,248	May 1	1,399,083	910	248	7	1,345,010	
1,400,248	,, 8	1,399,156	835	248	9	1,343,104	
1,400,284	,, 15	1,399,170	824	248	6	1,340,618	
1,400,248	,, 22	1,399,194	797	248	9	1,339,468	
1,400,248	,, 29	1,399,205	786	248	9	1,341,687	
1,400,248	June 5	1,399,089	905	248	6	1,354,035	
1,400,248	,, 12	1,399,172	819	248	9	1,362,095	
1,400,248	,, 19	1,399,120	872	248	8	1,361,805	
1,400,248	,, 26	1,399,032	963	248	5	1,363,868	
1,400,248	July 3	1,399,130	860	248	10	1,367,609	
1,400,248	,, 10	1,399,333	658	248	9	1,369,722	
1,400,248	,, 17	1,399,236	757	248	7	1,370,683	
1,400,248	,, 24	1,399,166	827	248	7	1,376,567	
1,400,248	,, 31	1,399,181	812	248	7	1,386,853	
1,400,248	Aug. 7	1,399,182	811	248	7	1,390,988	
1,400,248	,, 14	1,399,206	788	248	6	1,383,387	
1,400,248	,, 21	1,399,089	902	248	9	1,374,161	
1,400,248	,, 28	1,399,227	764	248	9	1,367,535	
1,400,248	Sept. 4	1,399,267	725	248	8	1,367,450	
1,400,248	,, 11	1,399,272	721	248	7	1,365,843	
1,400,248	,, 18	1,399,175	817	248	8	1,361,786	
1,400,248	,, 25	1,399,210	780	248	10	1,358,727	
1,400,248	Oct. 2	1,399,191	799	248	10	1,360,756	
1,400,248	,, 9	1,399,213	778	248	9	1,361,866	
1,400,248	,, 16	1,399,331	662	248	7	1,362,475	
1,400,248	,, 23	1,399,302	689	248	9	1,360,791	
1,400,248	,, 30	1,399,245	748	248	7	1,361,757	
1,400,248	Nov. 6	1,399,270	723	248	7	1,365,106	
1,400,248	,, 13	1,399,271	720	248	9	1,365,680	
1,400,248	,, 20	1,399,183	807	248	10	1,363,386	
1,400,248	,, 27	1,399,110	882	248	8	1,366,004	
1,400,248	Dec. 4	1,399,124	870	248	6	1,375,670	
1,450,248	,, 11	1,449,126	867	248	7	1,398,213	
1,450,248	,, 18	1,449,221	773	248	6	1,416,989	
1,450,248	,, 25	1,449,138	851	248	11	1,428,182	

* Liable to fluctuation. † At 172*s.* 3*d.* per fine oz. ‡ From Nov. 13th "Coin other than Gold Coin."

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WEEKLY RETURN

for Wednesday in each Week, during the year 1946

(000's omitted)

9	10	11	12	13	14	15	16	17	18
BANKING DEPARTMENT									
Liabilities				DATES (Wednesdays)	Assets				Totals of Liabilities and Assets
Capital (14,553) and Rest	Public Deposits	Bankers' Deposits	Other Deposits		Govt. Securities	Discounts and Advances	Other Secnrities	Reserve (Notes) and Coin)	
£	£	£	£		£	£	£	£	£
17,864	23,507	296,507	63,951	Jan. 2	350,470	9,930	15,536	25,893	401,829
17,878	11,645	262,215	59,473	,, 9	284,830	10,789	13,880	41,712	351,211
17,896	20,151	221,297	58,466	,, 16	238,501	9,071	14,366	55,872	317,810
17,915	13,063	232,794	54,826	,, 23	229,995	8,326	14,267	66,010	318,598
17,930	10,971	279,668	55,892	,, 30	265,090	5,486	24,526	69,359	364,461
17,968	12,974	207,896	56,746	Feb. 6	205,875	2,642	20,083	66,984	295,584
17,981	11,899	238,456	54,126	,, 13	232,550	2,608	15,132	72,172	322,462
17,995	12,418	218,653	53,565	,, 20	198,910	11,014	14,159	78,548	302,631
18,014	16,670	234,489	53,036	,, 27	215,535	7,443	21,175	78,056	322,209
18,456	19,275	217,616	53,470	Mar. 6	201,905	14,223	15,476	77,213	308,817
18,490	13,810	220,929	53,609	,, 13	201,670	14,577	15,589	75,002	306,838
18,504	12,040	241,850	54,506	,, 20	215,320	20,401	15,472	75,707	326,900
18,523	9,863	249,066	53,976	,, 27	217,240	19,991	21,449	72,748	331,428
18,539	15,020	222,974	53,825	April 3	187,350	39,559	16,398	67,051	310,358
17,707	14,547	215,822	52,287	,, 10	183,510	39,550	15,083	62,220	300,363
17,753	16,209	211,751	52,983	,, 17	200,195	28,601	15,026	54,874	298,696
17,800	7,433	253,409	53,072	,, 24	241,545	22,418	14,785	52,966	331,714
17,847	9,080	238,934	56,637	May 1	222,300	20,765	23,140	56,293	322,498
17,882	14,096	226,042	51,183	,, 8	214,725	17,795	18,311	58,372	309,203
17,914	15,464	218,605	50,829	,, 15	208,375	16,719	16,780	60,938	302,812
17,949	16,298	245,497	55,661	,, 22	228,165	28,339	16,808	62,093	335,405
17,983	7,410	244,838	57,377	,, 29	222,345	16,671	28,553	60,039	327,608
18,003	8,110	254,569	54,241	June 5	254,570	15,671	16,802	47,880	334,923
18,053	11,726	247,847	52,760	,, 12	265,050	9.716	15,708	39,912	330,386
18,106	7,480	236,093	55,066	,, 19	249,245	9,645	17,534	40,311	316,735
18,126	5,308	285,973	56,452	,, 26	299,520	12,478	15,697	38,164	365,859
18,164	7,722	311,660	56,745	July 3	334,330	9,853	15,718	34,390	394,291
18,199	6,970	224,864	55,319	,, 10	247,823	9,977	15,416	32,136	305,352
18,232	7,474	257,636	55,929	,, 17	281,793	10,177	16,235	31,066	339,271
18,278	7,602	246,491	53,634	,, 24	272,748	10,793	17,355	25,109	326,005
18,305	7,062	238,742	54,437	,, 31	262,818	15,837	25,133	14,758	318,546
18,353	13,910	241,100	52,155	Aug. 7	274,198	18,282	22,502	10,536	325,518
18,376	33,842	242,995	52,417	,, 14	295,238	17,040	17,391	17,961	347,630
18,410	15,367	250,106	53,109	,, 21	278,708	13,839	17,227	27,218	336,992
18,439	7,045	307,621	54,009	,, 28	315,473	9,903	27,962	33,776	387,114
18,461	10,105	251,353	58,624	Sept. 4	275,746	11,145	17,829	33,823	338,543
18,494	20,093	246,800	55,733	,, 11	266,296	20,126	19,209	35,489	341,120
18,502	12,954	261,869	59,227	,, 18	285,506	8,378	19,058	39,610	352,552
18,509	9,280	302,917	55,478	,, 25	305,121	18,811	19,514	42,738	386,184
18,545	9,647	282,779	53,791	Oct. 2	293,731	11,772	18,608	40,651	364,762
17,704	10,354	267,569	52,894	,, 9	280,491	11,247	17,293	39,490	348,521
17,731	17,362	260,038	56,415	,, 16	287,226	9,248	16,294	38,778	351,546
17,758	14,822	293,728	54,162	,, 23	307,981	15,118	16,883	40,488	380,470
17,807	8,174	292,704	57,537	,, 30	299,861	9,541	27,294	39,536	376,222
17,841	19,490	266,750	54,883	Nov. 6	283,036	12,023	27,733	36,172	358,964
17,878	12,908	270,754	56,706	,, 13	287,021	17,657	17,976	35,592	358,246
17,907	10,907	291,775	54,598	,, 20	296,263	23,432	17,611	37,881	375,187
17,941	10,099	310,129	56,349	,, 27	309,618	25,313	24,287	35,300	394,518
17,974	9,838	279,573	54,131	Dec. 4	298,463	20,834	16,569	25,651	361,517
18,016	14,869	265,565	56,448	,, 11	258,033	27,233	16,398	53,234	354,898
18,038	11,952	276,220	56,418	,, 18	286,149	24,963	16,998	34,518	362,628
18,090	10,255	278,923	57,279	,, 25	311,798	13,606	15,792	23,351	364,547

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OVERSEAS TRADE OF THE UNITED KINGDOM
for the years 1938 and 1946

£ million

Class and Group	Imports (c.i.f.)*		Exports (f.o.b.)†		Re-exports (f.o.b.)†	
	1938	1946	1938	1946	1938	1946
I.—Food, Drink and Tobacco—						
A. Grain and flour	74·4	90·9	1·7	6·1	1·5	1·7
B. Feeding-stuffs for animals	11·4	2·9	0·7	0·3	0·1	0·1
C. Animals, living, for food	9·2	11·8	0·0	0·0	—	0·0
D. Meat	90·7	139·2	1·2	0·7	0·6	1·8
E. Dairy produce	80·0	115·1	1·1	1·2	0·7	0·5
F. Fresh fruit and vegetables	37·7	52·5	0·4	3·1	1·3	0·1
G. Beverages and cocoa preparations	46·5	61·7	13·8	17·2	6·1	6·1
H. Other food	56·9	98·3	12·1	16·9	1·2	1·8
I. Tobacco	23·3	65·6	4·9	18·0	0·8	0·9
Total, Class I	430·1	638·0	35·9	63·5	12·3	13·0
II.—Raw Materials and Articles Mainly Unmanufactured						
A. Coal	0·0	0·0	37·4	9·1	—	—
B. Other non-metalliferous mining and quarry products and the like	4·7	16·4	1·0	1·6	0·3	0·6
C. Iron ore and scrap	11·2	20·3	0·6	0·0	0·0	—
D. Non-ferrous metalliferous ores and scrap	16·3	22·4	2·3	2·1	0·9	0·2
E. Wood and timber	42·9	52·4	0·1	0·5	0·3	0·3
F. Raw cotton and cotton waste	29·6	44·6	0·4	0·6	1·3	2·6
G. Wool, raw and waste, and woollen rags	42·6	40·3	6·3	6·4	12·6	8·1
H. Silk, raw and waste, and artificial silk waste	2·1	1·3	0·7	1·6	0·0	0·3
I. Other textile materials	11·8	15·1	0·3	0·2	0·8	1·0
J. Seeds and nuts for oil, oils, fats, resins and gums	30·6	62·1	2·9	2·4	0·5	2·6
K. Hides and skins, undressed	18·2	27·3	1·1	2·0	9·6	3·9
L. Paper-making materials	16·0	18·5	1·2	0·5	0·1	0·0
M. Rubber	11·5	42·1	0·2	0·8	2·7	7·5
N. Miscellaneous raw materials and articles mainly unmanufactured	10·6	22·2	2·4	5·1	1·1	1·7
Total, Class II	248·1	385·0	56·9	32·9	30·2	28·8
III.—Articles Wholly or Mainly Manufactured—						
A. Coke and manufactured fuel	0·0	0·0	3·3	1·1	—	—
B. Pottery, glass, abrasives, etc.	7·4	2·3	9·6	27·6	0·1	0·0
C. Iron and steel, and manufactures thereof	14·8	9·4	41·7	80·0	0·2	0·1
D. Non-ferrous metals and manufactures thereof	40·8	41·6	12·3	37·7	9·1	1·1
E. Cutlery, hardware, implements and instruments	7·1	3·0	9·0	27·0	0·7	0·3
F. Electrical goods and apparatus	3·1	5·0	13·4	37·4	0·1	0·1
G. Machinery	21·8	13·5	57·9	113·8	1·0	0·3
H. Manufactures of wood and timber	6·3	9·9	1·2	1·5	0·2	0·0
I. Cotton yarns and manufactures	3·1	1·7	49·7	63·2	0·2	0·0
J. Woollen and worsted yarns and manufactures	3·8	4·3	26·8	43·6	0·5	0·3
K. Silk and artificial silk yarns and manufactures	5·0	2·3	5·5	27·3	0·5	0·1
L. Manufactures of other textile materials	4·6	10·4	10·7	21·8	0·1	0·2
M. Apparel	8·0	1·7	8·5	30·4	0·4	0·1
N. Footwear	2·8	0·8	2·0	4·9	0·0	0·0
O. Chemicals, drugs, dyes and colours	13·6	17·6	22·3	66·1	0·5	0·8
P. Oils, fats and resins, manufactured	44·1	82·8	5·4	6·3	1·1	2·7
Q. Leather and manufactures thereof	6·4	10·0	3·9	6·0	0·9	0·4
R. Paper, cardboard, etc.	14·9	11·9	6·9	14·4	0·1	0·0
S. Vehicles (including locomotives, ships and aircraft)	4·5	2·8	44·5	113·5	0·4	0·1
T. Rubber manufactures	0·7	0·0	1·7	5·6	0·0	0·0
U. Miscellaneous articles wholly or mainly manufactured	20·9	15·7	29·0	57·2	2·2	1·5
Total, Class III	233·7	246·7	365·3	786·4	18·3	8·1
IV.—Animals, not for Food	3·3	7·1	0·7	3·8	0·7	0·4
V.—Parcel Post	4·3	20·9	12·0	25·1	—	—
Total	919·5	1,297·7	470·8	911·7	61·5	50·3

* The value of the Imports represents the cost, insurance and freight; or, when goods are consigned for sale, the latest sale value of such goods.

† The value of the Exports represents the cost and charges of delivering the goods on board the ship, and is known as the "free on board" value.

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Vol. CX.] [Part II.

Journal of the Royal Statistical Society

PART II, 1947

Statistics and the Statistician in Industry

A Discussion before the Royal Statistical Society held on January 23rd, 1947, The President, The Rt. Hon. Lord Woolton, P.C., C.H., in the Chair.

Opened by Mr. H. T. Weeks

I was asked to open a discussion on "Statistics in Industry." I added "the Statistician," because in this case the player is more than the game. And since I do not know in detail what other people are doing, you will find that what I have to say has personal limitations which I hope can be forgiven in an Opener, though it might be thought unworthy of a Lecturer.

The pattern I want to follow is first to consider what we mean when we talk about statistics in business. Next, briefly how they originate and how they are used. And after considering what sort of character a statistician should be, I will suggest a few points on which we might concentrate discussion.

I suppose I ought to define where operating figures end and statistics begin, though I cannot hope to be very precise or academic in what I am going to say. I would not call the production records needed in planning "statistics," nor the customers' accounts. But the examination of the proportion of production in small lines or of trade in small accounts is, I suppose, "statistics" —which implies that we are talking about a use of figures beyond the bare routine necessities of the business. Co-ordinated statistics in this sense seem more common on the sales than the other sides of a business. And since it is the side I know most about, I would like to deal with it in some detail.

The first part of the job is straightforward reporting—the lay-out of returns whose complexity depends entirely on the absorptive capacity of other people, and whose frequency may vary from a weekly return on output to annual returns of great complexity and largely historical interest. These returns can be very simple or very confusing—it is usually a help to have them charted.

A lot of the statistician's work can be called the study of trends. The sort of points which come up are the relationship of the firm to the industry (measured by the production census, material consumed, employment, etc.), variations in sales in different areas and seasons, elasticity of demand and the reaction of sales to other forms of sales promotion. It is great fun to try to relate sales to various economic series with a view to more accurate forecasting of the future sales and costs of a business. Forecasting itself is an important part of a statistician's job.

In a slightly different category comes the analysis of the firm's distribution, using the word in the "census of distribution" sense. That means such exercises as the analysis of customers according to their size and type and a comparison with the distributive organization of the trade as a whole: the assembly of data on the margins and profits in retailing and wholesaling and similar efforts which will produce a much better dividend when the new distribution census has been taken and published.

Finally, there is the statistical side of what can broadly be described as marketing research, in which I include trying to measure the effectiveness of various sales promotion methods by controlled experiments as well as field enquiry among predetermined samples.

So far I have been talking about the statistics which arise on the marketing side of the business. In factory planning and production, statistics are for the most part of a rather different character, though two points of interest ought to be mentioned. The first is the question of quality control by sampling, which has been quite fully discussed in various places already and which I do not

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propose to describe since I know very little about it. It is obviously one of the few business uses of refined statistics. The other question of major interest is the measurement of output per head or P.M.H., or efficiency, or whatever else you choose to call it. I want to say something of this later. In other spheres of industry the statistics assume familiar forms, as in finance and investment, or in laboratory research.

How do these statistics originate? And how are they used? For the most part they should come forward as part of a long-term development of background information. Some of them are to give quick answers to some particular enquiry on which hangs a policy decision. In such cases the information is wanted quickly; any delay is a delay in reaching the decision; speed is more important than over-refinement. How the figures are mechanically derived must depend on what the system is. With any system, especially with punched cards, the statistician's job is to foresee the possible bits of information which will be wanted at various times in the future, so that they can be thrown up as a by-product of the system and do not demand an *ad hoc* analysis. It is important to use a sample whenever possible because it saves so much time and money, and that justifies a certain amount of work in predetermining what combination of customers, grounds, towns, etc., make a reasonably representative sample for the country as a whole.

How are statistics presented and used? I can best reply by a series of dogmatic and apparently naïve statements. It is no good presenting statistics with the proper qualifications. The statistician himself has to sort out what the qualifications mean and how far they justify him in going. He has to concentrate on presenting certain conclusions in a form as simple as possible; in the majority of cases his final answers need only be in quite broad proportions. He should avoid the temptation to submit all his calculations and processes to people who are only concerned with the final answer. But this means that his judgment must be accepted and trusted. As I shall repeat later, it is important for the statistician to have executive responsibilities. He should certainly be present when his material is being discussed, and since all such discussions always range over a wide field, he is helped if he has a good enough memory for figures to keep people straight on proportions and the major facts of history.

What sort of person is it who should carry out this statistical work? I have been responsible for statistics in a large firm for most of my working life, apart from six years which I spent in the Civil Service doing a quasi-statistical job. During that time I have never used mathematics which I did not use at school. I rather wonder if I am competent to open a discussion, for I am certainly so rusty in my knowledge of theoretical statistics that I could not pass the proposed examination by this Society. And I ought to add that I have not relied upon expert help. In the Ministry of Supply, for example, my senior staff consisted of a couple of actuaries who were certainly qualified in their particular form of mathematics, the advertising manager of a weekly paper, and a couple of economists, one of whom was a classic and was not very good at arithmetic. All of them paled at a correlation. I did indeed have one qualified statistician, but since none of us could understand what he was getting at, we had to train him to be a useful member of a statistical department. What do I mean by that?

First of all we had to learn what we were talking about. We had to know precisely how the figures which were our daily work were arrived at and what were the things which they measured. What went with what, what was important, what was believable and where to look with the eye of suspicion and doubt. Our most useful purely statistical work was in selection and addition. We would take a mass of statistical returns on which everything seemed of equal weight, and from that select what needed attention and publicity. In those returns a trivial difference in description would mask the difference between something of vital importance and something of very little interest. We could only do this properly by having a close detailed knowledge. And then we had to add together shells and guns and battle-dress to show how output was moving, and how the trend of output compared with the trend of manpower, of materials and capacity. The piece of statistical technique we used was index numbers.

All this was work which required considerable tact and discretion. Various parts of the statistical material we used—or to be less pompous, the figures—were known in great detail by individual experts (who grew in numbers and knew more and more about less and less), and we had to make these intelligible to people who were responsible for wide policy so that as they knew about more and more, they should not know less about it. And at the same time we had to convince the experts that we were not misrepresenting or insulting them by reducing their work

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to a single simple table. So we operated as middlemen, and it was of great importance that we should be trusted by both sides. We had to learn to write clearly and simply about tables and figures, which was a difficult thing to teach and a rare ability to find. We had to be in a position to produce a review for the War Cabinet or a fully documented programme for the Americans at a few hours' notice for which we depended on a mixture of good memory and good filing. But reporting became a little boring, especially as things got better, and the real fun was as we moved from reporting what was to deciding what should be. We had to prepare production programmes, and to convince those responsible that they were sensible and feasible when all the factors had been taken into account.

In business and in public administration the statistician must be closely concerned with policy, for his job is to guide those people who control policy, to remind them of limitations, to know how much it is possible to find out to make a better decision possible. He ought to develop fairly wide powers, though whatever his powers, the important thing is that he should get on well with the people with whom he works. That applies to most human activities, but it is more difficult for the wretched statistician, for the figures he presents in the course of his thankless job always give some ground for critical appraisal and people are sensitive.

His best friends will misquote his conclusions and then expect support. He will continually be asked to prove what he knows is not true. His soundest deductions will be dismissed by that frightful crack about lies, damned lies and statistics. The human tale of a single customer may outweigh the statistical evidence of ten thousand. He must, of course, have more than the admirable character needed for these trials; he must have a feeling for the statistical approach and sense of proportion, he must think quantitatively and have a wide knowledge of sources. He must be sufficiently open-minded to keep in touch with new developments. He must be able to convince in argument. He must be too good to be a mere statistician for long.

My experience has led me to two conclusions which apply to statistical work in business or in Government administration: first, that the personal quality of the statistician is far more important than his technical qualifications; and secondly, that the less the part that statistics play in his work, the more effective the statistician becomes. In the Civil Service anyone unlucky enough to be called a statistician was paid £200 a year less in consequence; in business the word itself—clumsily mispronounced—has irresistible comic overtones.

Now I would like to suggest some points for discussion—five of them.

1. How much scope is there for theoretical statistics in business? I ask this with some humility because I should not be able to apply them if I found there was much scope. Index numbers are a rather useful device, and there is a certain amount of statistical work (generally misunderstood) on the dispersions found in small samples—what else?

2. What sort of training should the statistician have? Obviously he wants some simple knowledge of statistics in the sense in which this Society uses the word, but mostly he needs the background of an economist and wide experience of the business in which he is concerned. How far have short courses of statistics proved of value?

3. What should be the position of the statistician in the business organization? Ideally it should be a transitional job—the bridge between the University graduate and the executive directorship. Should he have executive responsibility? What should his relations be with his colleagues? How should he be described? I think myself that statistics by themselves in either Government or business are always dull work. It is only when they are tied up with programmes, with research, marketing policy, budgetary control, that they become a reasonable occupation.

4. How can we keep business statisticians reasonably fresh and alive to what is happening? You will see from what I have said that they may glory in their ignorance. How can this be avoided?

5. What are the new developments of particular interest? To begin with, there are three very broad ones. The first is the greater amount of Government information which will spring from the general provisions of the Full Employment White Paper, and which are obscurely hinted at in the Statistics of Trade Bill. More specifically for those who are interested in the marketing side of businesses, is the forthcoming Census of Distribution, which will give an entirely new picture of the framework through which our distribution goes. And as a profession, I think we ought to make it clear that the filling in of these forms is not very difficult, and that the job when finished is going to be exceedingly useful.

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The second topic of interest is the measurement of variations in factory efficiency or P.M.H. It is most distressing with how little precision the effect of less hours or drop in the working week, of changes in the piece-rates structure, of technological changes, etc., have been recorded. Great national changes take place with the most fragmentary and probably misleading evidence of their probable effect. I do not believe they can be done by any central global methods; I think they must be built up from the individual and complicated factory unit. It is not too late to make an effort to co-ordinate this sort of work.

And finally, not only should the employer spend time and money on compiling valuable statistics, so should the Trade Unions; and my friends tell me there is a lot of development possible in that field.

Mr. PHILIP LYLE said that this subject was rapidly becoming of ever greater importance. The title covered a wide field, made still wider by Mr. Weeks's reference to certain measures such as elasticity of demand and P.M.H., which took them into the realms of economics, so that perhaps it was permissible to roam a little in that extensive and interesting borderland between statistics, economics and accountancy.

Mr. Weeks had laid emphasis on the application of statistical methods to the commercial side of industry. To much of this work the methods of mathematical statistics could certainly be applied. An interesting and instructive example was the determination of elasticities of demand by the late Professor Henry Schultz in his book *The Measurement of Demand*. He determined the elasticity of demand of many farm products, including sugar and cotton, over a long period of years, eliminating from the original data irrelevant long-term trends by such devices as trend ratios and link relatives, and submitted the reduced data to regression analysis.

In his (the speaker's) experience it was on the factory production side that the tools of modern mathematical statistics had the greatest scope. Quality control methods were best known because of their extension during the war, and were still probably the chief statistical methods used in the engineering industry. In the process type of industry with which he was connected, namely sugar, which was more akin to the chemical than to the engineering industries, quality control took a minor place, being used chiefly for such purposes as the control of automatic weighing and packeting plant.

The most important branch of statistics was, however, regression analysis, which was used for many purposes. A typical example was the analysis of weekly steam consumption in a factory with variations in output. In his firm these analyses had been made in each factory every half year for many years, and, with few exceptions, the records had the same characteristics. The scatter diagrams showed that the relation was obviously linear. The correlations were high, the coefficient lying normally between 0·90 and 0·97. The intercept on the steam consumption axis was positive, giving an estimate of the amount of fixed steam used which was independent of the output, and accounted for by such things as radiation losses, stopping and starting at week-ends, etc. The regression coefficient, or slope of the line, was a measure of the marginal steam consumption. Similar analyses could be made for power, labour, etc., not only for the whole factory but for individual departments.

Similar regular analyses were made of production costs on output, omitting from the cost figures the known "overheads." The fixed costs thus isolated, which were surprisingly high, were accounted for by the cost of the fixed steam, fixed power, fixed labour, etc., already referred to. An estimate was also obtained of the marginal cost, which was important for many purposes and had now become part of the routine product cost-accounting system.

If a factory was working flat-out all the time the variations in output were not sufficient to enable any analysis to be made, but, luckily for the statistician, if not for the shareholders, few factories were in that fortunate position.

Another interesting application of statistical methods which had been tried out recently was concerned with the design and analysis of experimental work, not only in laboratory research, but in work on the pilot plant scale and on the large scale where the cost in money and time could be very great, and where it was necessary to obtain the maximum amount of information with the minimum of experimentation. This problem had recently been thoroughly explored by Professor R. A. Fisher and others in the fields of biology and agriculture, and it was natural that an attempt should be made to apply those principles and methods, which had proved so successful, to their problems in industry.

The methods they were using involved no new principles and were based entirely on the analysis of variance. They were not, however, concerned merely with showing that some factors were barely significant or highly significant. They wanted to end up with a regression equation

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from which they could forecast with a known degree of accuracy what would happen with any given combination of levels of the various factors. An ordinary multiple regression analysis could, of course, be made, but with several factors with their curvatures and interactions they might be faced with the solution of ten or fifteen simultaneous equations, which discouraged them at once. This difficulty was completely overcome by using factorial designs with the various factors at equi-spaced levels, and all the variates, consisting of the linear and curvature terms for the factors and their interactions, in their orthogonal forms. A standard procedure applicable to any particular design resulted in a multiple regression equation, the actual amount of computation being quite trifling, however many variates were involved.

Mr. Weeks had asked what sort of man was wanted for a statistician in industry. There were two alternatives: (1) a man drawn from the industry with full knowledge of all the factory and process details, who could attend a short course in statistics at a university, or (2) a man who had been trained as an expert statistician, who had to spend a year or two learning the new trade. In a business of the departmental store type, where they had no "processes" in the usual sense of the term and where their operations were almost exclusively commercial rather than technical, he thought that an expert in the business would probably be the best choice if he were the right type and could be given a sufficiently long course in statistics. For the factory type of business he considered it essential to have an expert statistician, who, on joining, should be put through every technical department to learn the job. In the speaker's opinion he should be a first-class mathematician, otherwise he could not keep abreast of the latest developments. In most industries a great lack of sufficient knowledge of mathematics was felt. Youngsters came into the industry from the university with a degree in chemistry or engineering, but the majority had a knowledge of mathematics which the statistician would describe as barely significant.

Major G. PRYS WILLIAMS said that his experience began in the field of retail distribution, and continued in advertising and market research until the war. During the war he had the interesting experience of starting and developing the first active military statistical section outside the War Office. He returned to advertising and market research with an additional hobby interest in road safety research.

He agreed with Mr. Weeks's contention that the training requirements of the statistician in industry were: statistics, simple but good; economics, more comprehensive, and, if possible, better; and a knowledge of the business in which he worked, broader and more fundamental than either.

He was surprised that the two distinguished actuaries who worked with Mr. Weeks at the Ministry of Supply should have "paled at a correlation." His own work in the Army statistical organization was made more pleasant and profitable by the shrewd and enthusiastic co-operation of another pair of actuaries. Enthusiasm rather than their customary shrewdness seemed to have sponsored the following extract from their proposed standards for the trade test for the lowest grade of "Army clerk, statistical":

> "Approximation and contracted methods. Graphical representation and graphical solutions to simple problems. Square roots. Arithmetical progressions. Logarithms. Weighted means. Index numbers.
>
> "Knowledge and ability to use adding, and adding-listing (with split-register) and multiplying machines of the type in current use in Statistical Sections. Use of the slide rule.
>
> "Knowledge of geometrical progressions, classification of data, medians and modes. Basic appreciation of the curve of error, but no knowledge of the theory. Appreciation of the more common statistical fallacies, such as averaging a series of averages, justifiable degrees of accuracy, and loose use of the term 'significant' when applied to deviations, etc. Be capable of writing a précis.
>
> "Must have the ability to calculate standard deviations, but need not possess the theoretical background thereto. Must be able to plot a frequency distribution and calculate a coefficient of variation. Must appreciate the principles of sampling and heterogeneity when taking a sample. Must be able to calculate a coefficient of correlation and must recognize spurious correlations."

Would some friend that last "giftie gie us"! The final requirement alone brought a grain of comfort:

> "Typewriting (300 words in ten minutes)."

He had tested that—it could be done using two fingers!

He doubted whether two of the many officers whom he had trained in four years to take up important positions in the Army statistical organization could have passed the test—and certainly

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not more than one of many efficient clerks. In his training he had concentrated his advice on four aspects: simple statistical technique (latterly he had included *chi* squared); where to go for more fundamental advice or specialized techniques; the essence of the functions they were required to illuminate (which paralleled economics in industry); and the most complete and exhaustive knowledge of the organizations, their personnel and material, from whom and for whom the data were being collected and analysed. On that training a pre-war representative of a commercial druggist house went directly from a staff-captaincy under him to build and direct the statistical organization co-ordinating returns from land, sea and air Forces under the command of G.H.Q., India.

The business man would accept the statements of the chemist or the engineer far more readily than he would accept those of the statistician-economist. He thought there were two sets of reasons for this. If either the business man or the chemist carried out the experiment correctly it would work out the same for both. If done incorrectly the same explosion would confound them both.

If the business man interpreted his statistics correctly he naturally gave the credit to his innate judgment. When the statistician did so, some planning edict would, as often as not, swamp the predicted gain or loss. On the other hand, if the business man made an incorrect deduction, he was just as likely to achieve some striking but irrelevant success which made the error unimportant. Not so the statistician; particularly if his erroneous deduction was due to ignorance of the ways of the business. Then the finger would be prompt in pointing scornfully, and not only he, but statistics, would be blamed. The dice was always loaded against him, and the wise statistician should realize this and be very humble in consequence. He should also realize the tremendous authority of the sample of one.

The statistician more than others was required to know his business. Statistics enabled the like and the nearly alike to be bundled together and treated as one. What would strike the layman as vagueness in words might be concealed from him in the mystical clarity of the average. Against the mathematical "lies, damned lies, and statistics" could be set the literary "lies, damned lies, and plausibility." Both depended on two requirements, the ignorance of the hearer and the tendentiousness of the speaker. It was because of this that he took issue with Mr. Weeks's third point, that the position of statistician in a business organization should be transitional—a bridge between the university graduate status and the executive directorship.

The executive director required certain qualities besides balance and judgment. He should be enthusiastic, capable of concentrating effort in a determined direction, flexible, opportunist, open to compromise when this preserved his essential ends, and actuated by a strong sense of the possible. His need for objectiveness was not as great as that of the statistician, since by his efforts he aimed to alter the environment. These were not the ideal qualifications for a statistician. If his function was to provide the factual basis for executive decision he must, above all things, be objective and neutral himself. Having currently to discharge both functions simultaneously, the speaker could testify to the difficulty.

He thought that Mr. Weeks did a double disservice in dangling this carrot. It could make the statistician too ambitious so that by becoming a bad servant he might lose all. It could also make the hitherto happy statistician unnecessarily dissatisfied. One could be happy as a superb recorder of history. The historian who also made history was rarer, and who knew whether he was happy? There were more Trevelyans than Churchills—and Trevelyan was protected by copyright from the maltreatment and destruction of his great works by others.

Let the statistician who was equipped for executive work take it up by all means—he would be the better executive for his statistics—but the economist-statistician of an objective turn of mind could also serve. He could make good executives better executives by reason of his statistics. But whether the statistician was a staff officer to himself or to other executives, his most difficult problem was the same. It was that of finding out what both the apparent and the real problems actually were in clear-cut terms, providing answers to both which were equally clear-cut, and then avoiding the pitfall of defining the problems in terms of the answers it had been possible to obtain. Research in industry should always be the servant of the problem, and the statistician must see that the rôles were not reversed.

Dr. Isserlis said that it was always interesting to hear the views and experience of those who had been in a similar walk of life to one's own, and therefore he was interested in Mr. Weeks's summary of his experience as a statistician and his reaction to his environment. His first feeling was that Mr. Weeks was extraordinarily pessimistic on two points. One was about the people who employed statisticians to advise them. The previous speakers, Mr. Lyle and Major Prys Williams, had dealt with that point. The statisticians with whom Mr. Lyle and his colleague had been in contact had succeeded in putting over their point of view very clearly. The distinction

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between the employer and his technical adviser must be appreciated. A shipowner, for example, wanted to build a ship and knew what he wanted. The province of his naval architect was to tell him what conditions must be satisfied if his object was to be achieved.

Again, Mr. Weeks had suggested that forecasting results was an important part of the statistician's duty. He thought there was a misconception there. Statisticians and business men, like all other sensible persons, frequently used inductive methods—they could not help it. He himself had been trying for years, not unsuccessfully, to convince his employers that forecasting as distinct from induction was not part of the statistician's job. Anyone could see forecasting in operation on Derby Day at Epsom. They could see it also in many pages of print in the United States, but he would be very sorry if it became accepted that forecasting was part of the duty of the statistician. It was the statistician's business to say that it could not be done.

He thought also that Mr. Weeks took up too pessimistic an attitude in his suggestion that the training of the mathematical statistician was of small use in industry. One answer to that had been given by Mr. Lyle, but the answer could perhaps go deeper. There were many occasions in the work of the statistician where there was no direct need for the immediate application of the mathematical training he had acquired before he came into industry, but indirectly this mathematical training gave his advice a greater value than it would have had otherwise. A little knowledge, even of statistics, was a dangerous thing.

Here the speaker referred to sampling. It was possible to take the large sample of seven million Londoners and base on it an incorrect conclusion about 45 million people in the United Kingdom. On the other hand, a consignment of thousands of tons of grain from overseas might be accepted and priced correctly on the basis of a sample obtained by the trader simply putting his hand into a sack and examining what he withdrew. It seemed to him there were occasions when the mathematical training of the statistician proved of great value, even though it was not used in a great part of his ordinary work.

In the same way, a doctor might spend most of his time in dealing with simple childish ailments like measles and the common cold, but that did not mean that the deeper knowledge he had acquired in his professional training was superfluous. It might not come into use often in his experience, but it was of immense importance to have it there. He himself, in dealing with such unmathematical things as the charges levied by railways companies at docks, had had to use some such analysis as Mr. Lyle had referred to, in order to isolate the constituent in the charges independent of the post-war rise in the cost of labour and materials. Such an analysis need not appear in a final report, but the ability to make it was a necessary part of the statistician's training.

He desired to say one more thing with regard to executive or administrative positions in business. He considered, contrary to Mr. Weeks, that the question whether a statistician would make a good administrator or a good executive officer was quite irrelevant to the present discussion. The question was whether a particular man would excel in administrative or executive work, and he might do that in spite of being a statistician.

Mr. C. T. BRUNNER thought that the discussion so far had brought to light what he believed to be one of the fundamental facts about statistics in business, namely, that there were two quite different problems—statistics in manufacturing industry as described by Mr. Lyle, and statistics in the industries which were mainly distributive. His own experience was entirely in distribution, and from that point of view he wished heartily to endorse everything that Mr. Weeks had said, though he did not think he had said quite enough.

In the course of his paper Mr. Weeks had used the phrase "a mere statistician." That phrase told a great deal, and quite truthfully, about the position of the statistician in industry. Having himself at one period of his business life been a statistician in industry for thirteen years, he thought it was very doubtful whether the statistician as such had a place in distribution unless he could enlarge his functions to cover a wider field than statistics only. It might be useful to suggest a few directions in which he could do so.

In spite of what Dr. Isserlis had just said, forecasting was of great interest to those who controlled policy in all businesses, and the statistician—who should get his name changed to something else as soon as he could—must interest himself in programmes of future sales, estimates, and all sorts of things from the point of view of the position as it was likely to be in the future. The statistician in distribution would possibly tread a good deal on other people's toes, and should therefore move very carefully and tactfully. He would suggest a few directions in which the statistician could be useful, and enlarge his sphere from that of a "mere statistician" to something which was quite important in the business, without necessarily being an executive director.

First, there was the question of distribution and transport costs. Costs were prepared by accountancy departments, which very often regarded their functions as limited to the mere production of particulars of costs. The statistician could and should interpret those costs.

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The second and perhaps more important side concerned price policy. A price policy should be a scientific policy based on statistical knowledge of the condition of the market. The statistician or his department must be in a position to analyse the market. He must know how much of the total market his firm was doing, and, if it was losing, why and where and to whom it was losing. The statistician could build up a position in which he became in effect adviser to the Board on price changes. Apart from prices in general, there were things such as rebate scales and prices at which forward contracts for supplies could be made, and the statistician could develop usefully and effectively along those lines.

The next field in which he thought there was a scope for the statistician who had developed a little beyond statistics was what for want of a better term he might call public relations work. There was need for someone with a knowledge of the economic basis of the business, who really understood it in an all-round way; and the statistician with this knowledge might be able to talk to the Press and others and tell them such of the facts as the policy of his directors would allow to be told.

During the last eight years or so there had been an increasing interplay between business and Government departments, and a large part of this was concerned with economic matters. The statistician (or ex-statistician if he had managed to change his title) was perhaps the obvious and natural person to be handling that side of his firm's activities.

To deal with price and rebate scales involved very close working with the sales people. The handling of "public relations" might involve the risk of overlapping with publicity departments, and that too called for tact. Interpretation of costs might occasionally create trouble with operating departments, but the statistician must be a man who could go into any department and "catch on" with his colleagues. He would suggest therefore that there was a field for the statistician in distribution business which had little to do with theoretical statistics, and which was wider than Mr. Weeks had suggested for his first stage and narrower than for the second stage, namely, the executive director.

Mr. ZENTLER said that he was in the awkward position of having to side with the mathematical statisticians without himself being one of them. He had three brief points to make. The first was a purely logical one. It appeared that those speakers who had said that there was no need for mathematical statistics in business were not themselves mathematicians, and it was, to say the least, curious that people without the necessary technical knowledge of theoretical statistics—Mr. Weeks on his own admission was one of them—should express themselves on the usefulness of that technique in business. It was difficult to see how this argument could be answered.

His second point referred to statistics in distribution and marketing. In spite of his own relative youth he had had experience in this field, and speaking from his own experience, he could say that he had applied with good results mathematical statistics to business problems. He had used multiple and partial correlation technique to fix sales quotas, and analysis of variance and the chi-square distribution to determine the efficiency of salesmen.

Market research was doubtless also within the field of distribution and marketing. How it could possibly be argued that sampling theory was not needed in research which was based essentially on sample surveys, was something he could simply not understand.

His third point was concerned with forecasting in business—that is, the projection of economic series into the future; on this subject he entirely agreed with what Dr. Isserlis had said, though he might not have put the point in quite the same way. He thought that what Dr. Isserlis had in mind was that in the present stage of development of statistics no honest statistician could say he was able to make business forecasts based on respectable statistical techniques. If business men had had a look at Mr. Kendall's recent work on time series, which probably represented the latest development in this field of statistics, they would not be so self-confident about the possibility of making statistical forecasts of economic events. The difficulty lay partly in the subject matter itself, partly in the absence of data, and lastly in the fact that even if these two difficulties could be overcome, no business firm would allow their statistician to go to all the trouble serious forecasting required, simply to discover something which they thought they could find out for themselves. What one called forecasting in business could not, by any stretch of imagination, be considered scientific work. It was giving a pompous name to something which involved nothing but the most elementary rules of arithmetic, and which was, moreover, thoroughly discredited by now.

Dr. EASTERFIELD desired to take up the cudgels on this question of forecasting. What was meant by forecasting? Supposing it was hoped very soon to take clothing off coupons. It was essential in that case to find out just what the demand for clothing would be: whether, in fact, as soon as coupons were taken off, there would be a raid on the shops and the shops would

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be cleared out of clothing as by a plague of locusts. It seemed to him undoubtedly necessary to get a direct answer on such a point. If the statistician were called upon to say just how much clothing would be bought when coupons were taken off, the statistician was quite justified in saying that the answer was not there; but it was reasonable to go to the statistician and ask him to look at the facts and try to give an answer within some sort of limits of error. It might be an answer which had a limit of error of plus or minus 5 per cent., or a range of two to one; but even such an answer might make it quite clear that proposed action was, or was not, feasible.

His view was that when a statistician was asked to forecast he should be prepared to do so within the limits of error which he fixed, and even at times to say that the data were so extremely doubtful that he just could not do it; but it was reasonable to ask him to do it. A statistician should think out what he was trying to do, and do his best to give an answer with all reasonable care.

Mr. F. J. Anscombe said that a discussion such as this should touch if possible on all aspects of the subject, and he would like to say a word about the use of technical statistical methods in industrial production. Statistical methods had been widely used for quality control during the war, and an interesting review of American experience had recently been given to the American Statistical Association (by H. Working, *J. Am. Stat. Ass.*, **40** (1945), 425). He would like to mention two directions in which further work of a theoretical kind remained to be done—and would be done, during the next ten years. The first was in the design of sampling inspection methods. Inspection was an essential feature of mass production. When the article had been made it must be tested, and often the most efficient kind of inspection was sampling inspection. There was room for further investigation both into the physical process of drawing samples and into their interpretation when drawn. An excellent illustration of what he had in mind was provided by Mr. G. A. Barnard in his paper to the Research Section of the Society a year ago.

Another direction in which research was called for was in investigating the performance of machines. Many persons—quality control experts and others—had accumulated a great deal of experience regarding the standard of accuracy to which machines were capable of working, and probably much useful work remained to be done in collating that experience. But there was room also for fresh investigation as, for example, the investigation carried out by Mr. D. Newman, and recently described to the Industrial Applications Section of the Society, on the accuracy of some automatic gauging machines. Work of this kind was essential for the intelligent specification of tolerances in designs, and also affected the possibility of devices such as selective assembly.

He would not suggest for a moment that these were the only two possible lines of development, but one might as well be specific and mention two. From them could be drawn a number of interesting subjects for Ph.D. theses. He hoped that research students at the Universities—not only mathematical statisticians, but also engineering students—would give their attention to questions of this kind. He believed that few were doing so at present, and suggested that here was a fruitful field of research.

Mr. Tomski said that he had listened to the discussion with great interest. It was obvious to him that there were two distinct aspects of the subject, one theoretical and the other practical. When discussing the place of the statistician in industry one must consider two different classes of industry. In some organizations the value of statistics was widely appreciated, while in others those responsible were determined not to listen to statistics at all. In his experience the pharmaceutical industry belonged to the latter class. In order to act as statistician and to ensure that statistics were being used to the best advantage, one had to be more than a mathematician or a common-sense business man. One also had to be a psychologist.

He had been very much pleased to listen to Mr. Weeks's paper for this very reason, and whatever individual opinions might be on forecasting, his own method of approach had always been to extend the scope of his department by every possible means. Being a chemist as well as an economist he had certain advantages, and had received a little more co-operation than others would have been able to get.

During the nine months he had been employed as statistician in the pharmaceutical industry, figures had come to mean something in his own concern. Fact-finding and forecasting had become a routine machinery, and he had always been careful to point out the limitations under which such forecasts were given. In time, he felt sure, an efficient department dealing entirely with statistics would be developed, and he believed that it would probably be the only one possessed by a pharmaceutical firm in this country. He was fortunate in that his firm employed 2,000 people.

Mr. L. T. Wilkins said that, as Mr. Lyle had stated, the industrial statistician had, in the past, borrowed many of his techniques from biological statistics. In industry at the present

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moment the biggest problem was the human problem, and they might now try borrowing some of the techniques of the psychologists. He had in mind a suggestion by Elton Mayo that there was a group consciousness underlying the production efficiency of work-people. That was a line of research for the industrial statistician. Could this factor be proved to exist, and if so, how could it be measured and harnessed to efficiency?

Another point worth consideration was that since it was known that the human body did not react to temperature or humidity as such, but mainly to a function of the two, it was essential to measure and assess these and other factors which give the human body a sense of well-being. He was himself working on this problem at the moment.

He was also particularly interested in research into the causes of accidents, petty breakages and similar incidents. He thought there was plenty of scope for work with a view to finding a general factor which might underlie these incidents. He had already found a high correlation between accidents and morale and other socially based elements which he measured by means of questionnaires.

Industrial statisticians should start now, perhaps, to consider the use of techniques which might lead to a solution of some of the human and man-machine relationship problems at present facing industry.

Mr. A. J. H. MORRELL said that there was a general impression that quality control represented the only application of statistics in industry, and he was glad that previous speakers had drawn attention to that fallacy. There were several applications of statistics which had not been mentioned in the discussion. He would like to hear more about personnel selection in industry. There was a great deal of work still to be carried out by psychologists in that field. Then there was the question of market research in industries not producing consumer goods. Not much work had been done in industries of that nature.

He agreed that the statistician must understand the material with which he was dealing. It was desirable also that the executives and administrators should be fully alive to the possible uses of statistics, and should take the statistician into their confidence. Many applications of statistics in industry must be overlooked simply because there was no competent person in charge of operations who was aware of their possibilities. He knew that was true of service departments, and it was probably true of industry.

Mr. R. G. FORRESTER, who described himself as a statistician turned quasi-administrator cum administrative analyst, said he spoke with the bias of one who was an economist. To that extent he agreed with Mr. Weeks that a good basis for the statistician was a training in economics plus a detailed knowledge of the business, and that knowledge of the business should extend to a knowledge of what happened in the works and how the goods were actually produced. Mr. Weeks had spoken of two qualities in the statistician—a good memory and a good filing system. To this he would add a third, namely, a good imagination. By that he did not mean the ability to produce figures out of a hat, but the ability to look at figures and see what significance other than their surface significance they might have.

The question had been asked whether the statistician would make an administrator. In his experience the training of a statistician or of anybody else trained to deal with facts was a highly desirable background for administrative and executive work. It would be useful to have an administrator who realized it was necessary to examine the facts before one could make realistic decisions, and this applied both to industry and to government. The training of the statistician, with his ability to assess facts, was a good preparation for the work of administrator and executive director. Such a man, able objectively to assess what he wanted to reach and to decide where pressures should be applied, was in a better position than the man who merely knew that he wanted to put pressure somewhere.

On the question of mathematics, he had often felt that it would have been useful in business if he had had a better grounding in theoretical mathematics and the application of theoretical statistics. It was important to have mathematical statistics at one's command even if one did not have to use them. One would at least be able to assess their inappropriateness.

He did not share Mr. Weeks's view, which was, apparently, that in the business organization statistician was only a transitory state on the route from university graduate to executive director. It was quite pointless to discuss the statistician if one was saying at the same time that he had no permanent place. He thought, on the contrary, that he had in fact a place in every department. He believed also that the statistician should do forecasting. Somebody had to produce forecasts, and the statistician, imperfect as his technique might be, was better qualified to give the answer than most other people who might be asked to do so.

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Mr. L. J. GOLLOP said that, by amending the topic of discussion to include "the statistician" Mr. Weeks had made a change of substance. The place of statistical technique in industry was a different question from the place of the statistician. Statistics embodied techniques useful to apply to a given end, but not particularly useful in themselves. There were very few pure statisticians, just as there were very few pure mathematicians, but the number of people interested in those techniques was very considerable. The questions, "what use is the statistician in medicine?" and "what is the value of a knowledge of statistical technique to a doctor?" would receive different answers. A different answer would be given to the question, what was the place of a pure statistician in industry? from the question, what was the value of a knowledge of statistics to an economist or an industrialist?

With regard to forecasting, the person best qualified to do this was the economist. A knowledge of statistical technique was obviously useful, but that technique could only be usefully applied if its possessor had the necessary background of knowledge, embracing both theory and the actual data, given by a close and intimate contact with the industry concerned. With a knowledge of the economic theory lying behind the situation, of the technique to be applied, and of the limitations within which the data could be quantitatively expressed, then statistical technique could be of very great value in forecasting, which was essential to industry, particularly where large investments of fixed capital were concerned, or demand was liable to wide variations.

In this Society they had often heard speakers point out the gross inaccuracies of deductions drawn from figures—inaccuracies often solely attributable to lack of knowledge of the data, or lack of appreciation of the fact that what appeared to be a clear and concise description of an entity was in fact a description of a category which covered many different things. Many of them would recall references by Dr. Snow to grossly inaccurate deductions drawn from figures relating to the boot and shoe industry because the person making the deduction, while an expert statistician, had an inadequate knowledge of the details of the industry concerned.

Thus the questions of the place of the statistician in industry and the place of statistical technique in industry were separate and distinct, and this probably lay at the root of the short shrift that mathematicians appeared to receive in the present discussion. There was undoubtedly a field for the application of these techniques, provided that the person trying to apply them was not only a statistician but also had the proper background of knowledge of the relevant theory and of the data to which the theory was to be applied.

Dr. HERDAN wished to draw attention to one aspect of the subject which had not been touched on in the discussion. From what had been said so far it seemed as if objections to the application of statistical methods in industry could be raised only on the grounds that they were regarded as being too refined. But it was of interest that in certain branches of industrial activity statistical methods were considered to be of little use because they were not refined enough.

In the recent publication *Industrial Experimentation*, issued by H.M. Stationery Office, an example was given of multiple correlation using certain chemical variables. The regression at which the author arrived was a linear one. This gave rise to a controversy in the chemical journal *Chemistry and Industry*, where the statistician was reproached for having overlooked the fact that other variables than those considered by him must be taken into account, and that the relation between his variables was generally not in terms of the linear regression equation, but was a functional relationship which had previously been established. The speaker did not mean to support that criticism in the special case referred to, since the author of *Industrial Experimentation* had given a perfectly reasonable explanation of his procedure, but it was interesting as a warning in general. The statistician in industry had to be careful not to overlook previous work which had been done on the variables which he was about to correlate. Regression equations as developed by statistical methods were valuable only if nothing better was known about the relation between the variables. An established functional relationship was always preferable to the stochastic relation embodied in the regression equation.

This led to another problem. Since statistical calculations were by no means the most complicated mathematical procedures applied to industrial problems, why were statistics so often objected to on the grounds of over-refinement? The reason seemed to be that the manager, though well aware of the amount of mathematics used in a certain manufacturing process, did not attempt to master, or even to judge, those methods belonging to the domain of physics or chemistry, and often thought that statistics was something that could be learnt in a week. When he found himself mistaken in that, he was apt to mask his disappointment by putting the blame on the method.

It was, however, only fair to add that a certain amount of sound statistical knowledge, as much, say, as was necessary to carry out intelligent quality control work, could be acquired in a short time, provided one studied the matter properly. In the speaker's experience, foremen

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in a factory succeeded in doing this in three to six months, whereas the higher one went in the hierarchy of management, the less was the knowledge of statistics, simply because little effort was taken in acquiring that knowledge.

Mr. J. I. MASON said that he started life as a pure mathematician, went through the University, and then felt pure mathematics should be "applied"; so he became an economist, and had since been through one type of business and another, including a "slight lapse" into the Civil Service. He thought one could best sum up one of the great needs of the present day, that of the education of the executive, by a simple story. A certain executive, having seen the figures which a statistician presented, said to him, "This is amazing. How did you get these prices? They have not been published yet." The reply of the statistician was, "Well, I went to my retailer this morning and asked him!" The statistician in business must use common sense. Indeed, his work might be described as that of "crystallizing" common sense. This business of educating the executive was two-fold. It started, in a way, with the statistician himself. He had to learn a little of the psychology of the people with whom he was dealing and be tactful at the right time. The main trouble was the executive who was suspicious because he really did not know what the statistician was after. The statistician too often did not take the trouble to enlighten him, but was inclined to put down a set of figures and give plus or minus the square root of something or other as the limit of his (the executive's) choice.

The statistician should be a practical man. He must consider himself an adviser to the executive, but the trouble of the present moment was that the executive had lost touch with reality. He was stuck away in Room 654, and had no chance to talk to or observe people or trends. There was a great tendency for him to rely solely on the material produced by the statistician, since he was not always big enough to accept responsibility himself on the basis of mature experience.

The statistician should state the assumptions on which he based his argument something like this: "If that is so, and provided such and such, then this may happen." The executive was either prone or tempted not to hear all the first part and to say, "The statistician says, 'if *this*, then *that*'." It was possible for the statistician and executive to get on well together so long as each realized his own position, the one being the adviser and the other the executive or driving force. They should go along together rather like a driver and his mate. They should both aim to keep the lorry moving and to get it to its destination by the quickest, or safest, route, according to the type of load they carry.

Lord WOOLTON (from the Chair), in summing up the discussion, said that they would all be very much obliged to Mr. Weeks, and he hoped they felt as humble-minded as he did. If, some forty years ago, when he ventured to submit himself for Fellowship of the Society, he had realized what sort of person he was affecting to be he would have hastened to retreat. It was evident that Fellows of this Society were supposed to be Admirable Crichtons. If they were in business as statisticians, according to the discussion which had just taken place, they were required to understand all about the work of the cost accountants. But that was comparatively simple. Then they had to be prepared to tackle the much more difficult problem of being a *quasi* public relations officer, and able to explain to the Press and the world what the business they were engaged in was all about.

But they went on to greater profundities than that. They must be, according to some speakers, psychologists, economists and mathematicians. That was what the speakers in this debate thought of statisticians, and he thought Fellows would all be gratified to know that they were held in such very high esteem. He had long since become nothing more than a sort of ornament—he hoped—and that only for a passing period, in the statistical world. But he did come under the other categories which had been mentioned—not too respectfully—that evening, namely, those of a director—an executive director too—and a person who employed statisticians. He was bound to say that he thought Mr. Weeks was very wise when he divided the person from the trade, because, of course, it was true that any sort of person entering into business might well cease to occupy the position in which he entered and become something far more "highly paid," should he say, rather than something "better."

But for his own part, when he employed a statistician he wanted to employ a statistician, and not a person who was anticipating that at a date not too long delayed for his merits, he would proceed to occupy his own (Lord Woolton's) place as an executive director. He would personally rather deplore it—if Mr. Weeks would forgive him for some divergence of view in this matter—if the statisticians were to look upon the function they performed in business as a sort of bridge by which they might go on to a function which indeed was totally different in its nature and called for very widely different qualifications and characteristics. For his own part, he wanted to keep his statisticians, not in a glass case—because he wanted them to understand something about the

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business with which they were dealing—but in such a position that they would give him the facts he wanted, and he did not want them to take on a responsibility of forecasting. The statistician should give him the facts so that he himself could do the forecasting. To his mind, it was not a part of the function of the statistician to be able to enter into prophecy. All that he would ask him to do was to point out the way in which the facts indicated general trends. Beyond that it seemed to him to be the responsibility of the executive directors to forecast the facts of the future.

He agreed that the executive director who employed the statistician ought to pay him very well, and consequently to have a high respect for him, but he thought if the statistician became the executive director or if the executive director happened to have had the good fortune of some early training in statistics, then it was extremely important that when he became the executive director he should cease to be the statistician, because there again the functions were so separate, and he believed he fulfilled his purpose better as an executive director if he allowed the statistician to do his own work as an expert, presenting him with all the facts. The function of the expert was to state facts and to give expert advice. The function of the executive director was to listen to that advice and then come to his own conclusions, recognizing that very much had always been missed out when statistics alone were considered. Some people had, so to speak, in their bones the necessary knowledge for prophecy; others had it because they had surveyed carefully the knowledge accumulated by other people. On the whole, he preferred the latter method as being the one which was likely to give the better results.

He was personally grateful to Mr. Weeks—and here he was sure he was expressing the opinion of all in that assembly—for having gone to the trouble of preparing his paper and for starting this most excellent and wide-ranging discussion.

Mr. H. T. WEEKS said that he had found the discussion exceedingly interesting. He was duly humbled by some of the "cracks" that various people had made. Mr. Brunner had made two important points. There was a very profound difference between the use of statistics on the distribution side of the business, which he himself knew little about, and their use on the other side, about which he did know something. That was very true, Mr. Brunner's other point was that there were some quite useful and reputable people who did a job which was described as that of a statistician, but which was totally different from what was more generally understood by statistical work. One continually found confusion arising in people's minds because the same word was used to describe such entirely different functions and qualities as those which were required for these two jobs. He wished that some easy descriptive word was forthcoming which would cover fairly the job which he himself had been doing.

As a result of the ballot taken during the meeting the candidates named below were elected Fellows of the Society:—

Harold Ernest Caldwell, M.B.E.
Charles Ernest Everard Clinch.
Walter James Cottrell.
Margaret Louise Drukker.
Philip Frederick Dyer.
Bernard Edlin Gilbey.
Cristobal Hurtado.
S. Ramaswamy Iyengar, M.Sc.
Denys Arthur Jennings, M.A., B.M., B.Ch.Oxon.
Tej Bahadur Johri, B.Com., M.Com.
Herbert John Liddington, B.Sc.
John Maclean.
John Murray, M.A., Ph.D.
Milton Camargo da Silva Rodrigues.
Kurt Schiller, Ph.D.
Alan Edward Shave.
Harold Hartley Shepley.
Harold Charles Wallace.
Arthur Noel Whiting.
Albert William Willsmore.

Corporate Representatives

Albert John Walford, M.A., Ph.D., F.L.A., *representing* The Intelligence Bureau, Office of the Minister of Defence.
Avison Wormald, *representing* British Nylon Spinners, Ltd.

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THE STUDY OF INDUSTRIAL EFFICIENCY, WITH SPECIAL REFERENCE TO THE COTTON INDUSTRY

By L. H. C. TIPPETT

[Read before the ROYAL STATISTICAL SOCIETY, 26th February, 1947,
Dr. DAVID HERON, Vice-President, in the Chair]

Introduction

THE efficiency of British industry is under close examination these days, and the statistician is playing his part. The statistical approach that has received most publicity may be termed the "Census of Production" approach. Indices of efficiency such as production per man hour, and of factors affecting efficiency, such as horse-power per operative employed, are calculated for an industry from official statistics, largely those collected in the Census of Production; and comparisons are made, from time to time and from one country to another. These comparisons lead to various conclusions, which on publication give rise to much controversy.

Such studies undoubtedly have their uses, but they do not carry us far along the road of improved efficiency. The statistics are subject to so many reservations, largely of a qualitative kind—Dr. Snow's presidential address to this Society on "The International Comparison of Industrial Output"* deals with some of these—that only the broadest conclusions emerge, and the studies do little more than point to subjects worth investigating further. It must be accepted as established by such studies, notably by those of Dr. Rostas, that in many industries the British operative produces less per man hour than his American counterpart, but no responsible person would advise a slavish copying of American methods in the industries of this country. The conclusion has rightly led to further investigations like that of the Commission led by Sir Frank Platt. This Commission made a detailed comparison of technical practices in the cotton industries of the United States and England, and, in the light of technical experience, assessed those differences. The "Census of Production" studies have also presumably had a lot to do with the setting up of the Working Parties for various industries.

The statistician has a part to play in all these further investigations, collecting and collating data, and devising and interpreting measures of efficiency. There is a big field in the close study, by means that are largely statistical, of industrial efficiency. In some industries of this country there are comparisons to be made between firms that are likely to be more valuable than international comparisons, because within the industry of a country there are likely to be smaller differences in almost unalterable factors such as tradition (which is not to be dubbed as hide-bound and so dismissed as an entirely bad thing); the customs and attitudes of the workers and their leaders; the kinds of market served; and the accessibility of raw materials, labour and markets. Within such industries, the effects of the alterable factors can be studied more nearly in isolation, and the results are more likely to be immediately applicable. If such studies are to be effective, however, the approach must be analytical as well as statistical. For example, in order to find the optimum size of firm, it is not satisfactory to plot output per operative or some such index against, say, the number of operatives employed, and to take the maximum of this curve—if a curve can be drawn and a maximum discerned—as specifying the optimum size. The factors that determine efficiency, however it is measured, must be analysed into many parts, such as power supply, raw material supply, direct labour in the various departments, indirect labour, and ancillary services, such as welfare, management and office; and the effect of size of firm on each part must be estimated separately. This will probably require a mixture of empirical measurement and *a priori* reasoning.

The adoption of standard costing systems has been recommended by the Working Parties for some industries, and if this is done, and the full data are made available at some centre for analysis and collation, important lessons should be learnt. There are also other investigations, actual and potential, and it is my hope that the discussion this evening will bring some of them to light.

* *J. Roy. Stat. Soc.*, 1944, **107**, 1.

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I should be interested to know of what is going on in industries other than the cotton industry, and to learn from the experiences of other workers; and perhaps people in industries that are at present doing nothing along these lines may like to know what is possible. My contribution to the discussion is a description of work the British Cotton Industry Research Association at the Shirley Institute has been doing for some twenty years.

Our studies have been largely concerned with the utilization of machines and manpower. These are, of course, only two aspects of industrial efficiency, and we have at heart all that has been written on the importance of costs, quality of product, flexibility to meet world changes, and so on. We have largely confined our investigations to machines and men for reasons that need not be described, but the most important is probably that the data have been comparatively easy to come by. It will perhaps be counted as a sign of enlightenment on the part of the cotton industry that a central body like the Shirley Institute has had during the past years access to such information as I shall describe.

Our investigations have been mainly of two kinds, Detailed Surveys and Abbreviated Surveys.

Detailed Surveys

A detailed survey is designed to obtain a detailed and fairly comprehensive picture of the working of a factory: of the frequency and causes of machine stoppages, of the proportion of time the machines are stopped for the various causes, of the distribution of the operatives' time among their various activities, and of the machine and processing particulars and the factory layout. The making of these surveys was started by the Shirley Institute in weaving sheds in 1925, following along lines described by S. Wyatt* and J. A. Frazer.† Altogether, fairly comprehensive surveys have been made in about 40 weaving sheds and 9 spinning mills, and in addition, a large number of partial surveys have been made for special purposes.

In the early days we used the stop-watch to obtain much of the data, observing individual operatives and machines in turn and recording every event and its time of occurrence—the method of orthodox time study, but without the "rating" of the operative. This method was laborious and embarrassing to both observer and observed, and was largely, though not entirely, abandoned. I need not here elaborate on the difficulties of time study, except to point out that for many workers and their leaders the stop-watch has become the symbol of exploitation and driving, and of an attitude that regards operatives as machines rather than human beings; it is a great psychological handicap to have to use one in these studies.

Our main observations are now of two kinds, which we term "continuous" and "snap-readings." The continuous observations are made by observing individual operatives and machines continuously for periods of one-half or three-quarters of an hour, and recording how often during each period the machines stop for the various causes and, what amounts to practically the same thing, how often the operatives perform their various kinds of duty. The chief difference between these observations and orthodox time studies in their effect on the operatives arises from the fact that no stop-watch is in evidence, and that the operative can be made to feel that the machine rather than the person is under investigation. The difference in results is that our continuous observations yield rates of occurrence of the various events, not times. These latter are obtained from the snap-readings.

If any machines are stopped for a particular cause for an average of x per cent. of their time, and a large number of snap-readings of the states of the machines are taken at intervals uncorrelated with the occurrence of the stops, the percentage of readings recording the machines as stopped for that cause will tend to be x. The same is true for any state of the machines or activity of the operatives. This is the basis of the snap-reading method. The observer walks systematically round the factory taking snap-readings of machines and operatives, repeating this several times a day for several weeks, until enough readings have been taken.

An example of the kind of result is given in Table 1, and it will help to visualize a survey if this table is followed. There were 243 loom-hours of continuous observation, occupying an

* "Variations in Efficiency in Cotton Weaving," *Medical Research Council Report No.* 23, Industrial Fatigue (now Health) Research Board, 1923.

† "The Value of Stoppage Analysis with Special Reference to Weaving," *J. Nat. Inst. of Industrial Psychology*, 1926–7, 3, 422.

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observer for some 81 half-hour periods, six looms being observed at a time and each period being spent at a different group of looms, so that nearly all the 510 looms were covered. From the results, the rates in column (2) were calculated. There were 62,500 snap-readings on looms,

TABLE 1.—*Loom and Weaver Time Analysis. Mill A, 6 Looms per Weaver, all Cloths Combined*

Causes of Loom Stops and Operations of Weavers.	Number of Stops or Operations per Loom per Hour.	Percentage of Time Loom spent Stopped.	Percentage of Weaver's Time.	Seconds per Operation.
(1)	(2)	(3)	(4)	(5)
Weft skewering	7·3	—	23·6	19½
Weft re-shuttling { receiving attention	7·3	1·6	8·4	7½
Weft re-shuttling { awaiting attention		6·6	—	—
Mending weft breaks { receiving attention	2·8	0·7	4·3	9
Mending weft breaks { awaiting attention		2·3	—	—
Mending warp breaks { receiving attention	2·4	2·7	17·4	42
Mending warp breaks { awaiting attention		1·0	—	—
Other stops and duties	—	3·2	12·1	—
Supervision and relaxation	—	—	34·2	—
Percentage loom running efficiency	—	82·0	—	—
Number of snap-readings or loom hours of observation	243	62,500	9,300	—

A dash (—) means that there are no data appropriate to the corresponding cell in the table.

requiring about 120 rounds spread over 20 working days, with 5, 6 or 7 rounds per day. Of these readings, 1·6 per cent. recorded the looms as stopped and receiving attention for weft re-shuttling, and so on for the other percentages in column (3). It is inferred that the looms ran for 82 per cent. of their time; this percentage is termed the loom running efficiency. The 9300 snap-readings on the operatives were made on about 110 rounds, separate from but interspersed among the loom rounds, and spread over the same 20 days. From them the percentages in column (4) were obtained. Where figures appear in columns (3) and (4) in the same row, except for the row labelled Other Stops and Duties, that in column (4) should be six times the corresponding figure in column (3); discrepancies are due to random errors. The discrepancies are (8·4–9·6), (4·3–4·2) and (17·4–16·2). The mean times in column (5) are easily deduced from the figures in column (2), together with those in column (3) or (4) or both; I have calculated the last three times in column (5) from the unweighted mean of the corresponding figures in columns (3) and (4). This weighting has been chosen because the six looms of one weaver are not independent; only one can be receiving attention at a time, and as far as these particular stops are concerned the 62,500 snap-readings reduce to about 10,000 independent ones.

During the survey the observations are recorded in full detail, and results are usually reported in greater detail than is shown in Table 1. The "Other Stops and Duties" are analysed; results are given separately for different groups of looms, weavers and cloth qualities (in many Lancashire weaving sheds cloths of more than 50 different specifications are woven at the same time); and on occasions, efficiencies are determined for different parts of the average working day. For other textile processes except finishing, we obtain data of a similar kind.

Recently we have found it convenient to express spinning results in the form of Table 2. The basis of this is the O.H.P., i.e. the operative hours employed per unit of production, in this instance 100 lb. of yarn. It is the inverse of the P.M.H. (production per man hour), and is more convenient in use than that quantity since it is additive, and can be dealt with by the ordinary methods of cost accounting. The values in the "total" column of Table 2 are easily obtained from the ordinary mill records of the weight of material processed in each department in a given time—say four weeks—and of the operative hours of the various types employed in that processing.

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TABLE 2.—*Analysis of Operative Hours per Hundred Pounds of Yarn (O.H.P.) Employed in Spinning, Winding and Beaming. Ring Mill B.*

Type of Operatives.	Type of Work							
	Creeling.	Piecing Breaks.	Doffing and Gaiting.	Carrying.	Cleaning.	Miscellaneous.	Supervision and Relaxation.	Total.
Blow Room.								
All operatives	—	—	—	—	—	0·48	—	0·48
Card Room.								
Card tenters	0·10	0·02	0·01	0·24	0·12	0·32	0·22	1·03
Drawframe tenters	0·21	0·06	0·06	0·05	0·07	0·01	0·08	0·54
Speed frame tenters	0·84	0·21	0·42	0·46	0·49	0·07	0·72	3·21
Bobbin carriers	—	—	—	0·15	—	—	—	0·15
								4·93
Spinning Room.								
Spinners	0·76	0·92	0·02	0·02	0·83	0·01	0·76	3·32
Doffers	—	0·01	0·65	0·22	0·08	0·13	0·76	1·85
Ancillary workers	—	—	—	—	—	1·90	—	1·90
								7·07
Winding Department.								
Winders	2·46	0·33	0·18	0·36	0·09	0·09	0·99	4·50
Beamers	0·26	0·16	0·08	—	0·03	0·07	0·54	1·14
Carriers	—	—	—	0·55	—	—	—	0·55
								6·19
All Departments.								
Overlookers	—	—	—	—	—	—	0·60	0·60
*Totals	4·63	1·71	1·42	2·05	1·71	3·08	4·67	19·27

* Excluding higher management, office staff and mill services.

These values are then subdivided into the categories of the columns according to the percentages of a time analysis of the kind given in column (4) of Table 1. Table 2 is not highly accurate, since the O.H.P. of some of the operatives has not been subdivided (for example, blow room operatives have some time for relaxation, although this is not shown), and assumptions had to be made in distributing the operative hours of bobbin carriers and ancillary workers. However, the aim is to give a bird's-eye view of the labour distribution, and inevitably some detail and precision is lost. The point about the particular classification of the jobs into the types of work shown in Table 2 is that: apart from the effect of the speed and skill of the operatives the O.H.P. spent in creeling and doffing and gaiting are largely determined by the size of the packages (bobbins, etc.) used; O.H.P. spent in piecing breaks is largely determined by the quality of the material and the suitability of the technical conditions; and O.H.P. spent in carrying is determined by the factory lay-out and transport equipment provided, in addition to the sizes of the packages. The cleaning is routine cleaning that must be done continuously while work is in progress, and is additional to the thorough cleaning that is done weekly. The miscellaneous work can, of course, be divided, but few of the items would be common to all types of operative.

The snap-reading method of observation, which forms an important part of the basis of these surveys, has its errors and limitations. The reaction of the operatives can influence the results; there are random errors, a large part of which is describable by the binomial and Poisson distributions; and there are variations from time to time during the day and from day to day, that are in effect sampled. We have seen an evidence of part of these errors in the discrepancies between columns (3) and (4) of Table 1. The errors of all the observations made in these surveys have

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been studied fairly fully and I have dealt with them elsewhere.* Here it is sufficient to say that the surveys have to be made carefully and with a full awareness of the possibilities of error, that they require the ready acquiescence of the operatives, and that some experience with the methods is necessary. Given all these, results can be obtained that are reliable enough to be useful.

It is desirable to consider in what circumstances, other than psychological, the snap-reading method is suitable, as opposed to stop-watch timing. This is a matter for experience to decide, and my experience has not been wide enough to justify a dogmatic statement; the following remarks are suggestions. If a regular sequence of repetitive operations is to be timed, a stop-watch is possibly the better instrument; but if such a sequence is frequently and irregularly broken by such things as rest pauses, the snap-reading method may be useful for obtaining a good overall picture. Theoretically it is possible by the snap-reading method to analyse any job into elements as small as desired, splitting up the operation of weft reshuttling mentioned in Table 1 into such parts as taking up the full shuttle, stopping the loom, exchanging the empty for the full shuttle, restarting the loom, and laying down the empty shuttle. In practice it would require great observational skill to decide in the course of taking snap-readings exactly which part of the job is in progress when the observation is very close to a transition between one part and the next; and with a very fine division of jobs there will be a large proportion of doubtful borderline cases. Moreover, if the operatives' time is very finely divided, it requires a prodigious number of observations to attain a reasonable accuracy relative to the small magnitudes that are being estimated. Five seconds seems to be about the lower limit of duration of the jobs or parts of a job that are distinguishable. For timing long jobs, on the other hand, the snap-reading method is merely clumsy. An ordinary watch may be good enough for this. The snap-reading method is usually suitable, too, only for timing groups of machines and operatives and not for timing individuals. We once used the method for studying two operatives, taking snap-readings regularly at quarter-minute intervals, but this was perhaps an exhibition of virtuosity, to be imitated only where the stop-watch is prohibited. In short, the snap-reading method is suitable where the different jobs are many, of duration between several (say 5) seconds and several minutes, and irregular in occurrence and duration.

The time taken to do a survey depends more on the number of departments or groups of machines to be dealt with separately and on the detail required in the analysis than on the size of the factory. To cover all departments of the ordinary Lancashire spinning mill, including the winding department, completing the working out of the results as well as making the observations, requires about 52 observer-weeks. To cover a weaving shed requires about 15 observer-weeks. We think it desirable for the observers to work mill hours with the operatives, and to keep the routine of observations going at full pressure. Consequently the work is exacting and fatiguing, and no observer is expected to spend more than a few weeks consecutively at the mill.

Abbreviated Surveys

Abbreviated surveys are a recent development, and so far have been done only at spinning mills. They aim at producing for each mill data similar to those contained in the "Total" column of Table 2, but with a finer subdivision of the types of operative, together with details of the machines and processing particulars. The data are obtained largely from mill records, and for most mills can be collected in two or three days per mill. We have designed a series of schedules to record the data in standard form, and although these are sent to the mill in advance of the survey, the completion of the schedules is done by our observers. In response made to an approach by the Cotton Board, over 100 mills are voluntarily co-operating by giving facilities for surveys, and about one-half have been completed. The 100 mills form a good sample, covering one-fifth to one-quarter of the industry.

The aim of these surveys is to provide individual firms with analyses of their O.H.P. figures, to determine averages for the various sections of the industry and the spread about those averages, and to explain the variations as far as possible by relating them to technical and other particulars.

* "Uses of the Binomial and Poisson Distributions" and "A Snap-reading Method of Making Time Studies of Machines and Operatives in Factory Surveys," *Shirley Institute Memoirs*, XIII, 1934, pp. 35 and 73, or *J. Textile Inst.*, 26, 1935, pp. T13 and T51.

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There are three conditions that make us feel that this work is likely to be profitable. First, the spinning industry is comprised of hundreds of mills that can be classified into a relatively few types. Second, within each type there are substantial differences in practice that lead to substantial, and not necessarily essential, differences in O.H.P. Preliminary results suggest that there is at least a two-to-one "spread" in O.H.P. between mills producing similar yarns. Third, we know a good deal about cotton processing, so that our statistical analysis can be based on a sound technical analysis. The surveys are practicable only because spinning mill records for the various departments and specifications of product can easily be separated. Whether this is true in weaving mill records is doubtful, and remains to be seen.

Discussion of Results and their Application

This is not the place to enter into a technical discussion of the results of the surveys; to point out, for example, the effects of high draft spinning, or the place of automatic looms. And I cannot say exactly how far the results of surveys are used in determining policy or how far they should be used. But there is point in saying enough on these topics to illustrate the kind of results that come from these studies and the kind of use to be made of them.

First, I think that the surveys have produced little in the way of surprises or revelations. Like many statistical investigations, they have disclosed little that the discerning person cannot see without statistics, but they give quantitative expression to qualitative impressions, and by presenting facts objectively demonstrate things that people who are not discerning have missed.

The management of the individual mill where the survey is made has a first party interest in the report. Sometimes a survey is requested for some definite reason. Reorganization of the factory may be under consideration, and a good picture of the effects of the existing set-up be required as a basis. As a result of one weaving survey, we were able to suggest a suitable regrouping of looms with a view to equalizing the work on the operatives on the various groups; in other cases we have provided data to assist in working out new assignments of machines to operatives. In winding, where it is easier than in other processes to make individual mill arrangements for wage systems, survey results have enabled us to suggest relative piece wages for different yarns, so that the average operative can earn the same weekly wage irrespective of the yarn she is winding (we have nothing to do with absolute wage levels). On occasions, the management and the official representatives of the operatives have jointly asked for a survey to provide data which can be used in settling some point at issue. Surveys have been used to measure, in the factory, the effects of changes in technical conditions such as the relative humidity of the atmosphere. Since the middle of 1945 the Cotton Board has had in hand a number of mill experiments to investigate and demonstrate the effects of changes in equipment and labour organization on the P.M.H.; and the Shirley Institute, having its methods and staff for making surveys ready to hand, has been able to undertake the work of collecting and supplying the data on which the effects of the changes are assessed.

Some immediate purpose has accounted for a fair proportion of the detailed surveys, although each kind of purpose has accounted for only a very few. Most have been done because the management have a general interest to know how things are going: to compare the performance in their factory with the general average, to discover if there is any cause of inefficiency that has been missed, or (in a large firm) to provide the higher management, inevitably somewhat out of touch with the inside of the mill, with a critical account of the mill efficiency. It is only very occasionally that any very striking facts have been brought to light. For example, in one mill looms were shown to be stopped while waiting unduly for weft; qualitatively this was known to the inside manager and he had an explanation, but it was mortifying news to a responsible director. However, it is not always the spectacular that achieves most in the world of work, and some firms are realizing the value of maintaining a constant watch over operating efficiency by means of statistical records. In this connection, it is hoped that the abbreviated surveys will have an effect. In less than one year from now, each of over one hundred spinning mills will have an individual statement of the productivity of the operative staff, both in total and analysed according to processes and yarns, and will have consolidated figures for the industry with which to make comparisons. The remaining mills will be shown how to cast their own figures into the same form so that they can make comparisons.

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In all this survey work for individual firms, the function of the Shirley Institute is largely to provide and interpret data. We are prepared, on request, to discuss the technical and management implications of the results, and to estimate the probable effects of postulated changes. But we do not propose executive action; that is left to the initiative of the management.

As a central body serving the whole industry, the Shirley Institute is concerned to summarize and generalize the results of the surveys as far as possible, and from time to time general reports are made to members of the British Cotton Industry Research Association in confidential publications from the Institute. No results for particular firms are disclosed without permission, but all results are used in the general digests. Care must be taken, of course, to allow for special conditions obtaining at the time of the surveys: for example, since 1919 changing political and commercial factors have predominated over technical factors in the working of many cotton mills, and comparatively seldom have we surveyed a mill operating "normally." Moreover, the limited scope of the data so far to hand, especially the few mills covered and the absence of information on costs, must be remembered. Nevertheless, something has been added to the store of general and moderately exact knowledge of the technical anatomy of the industry; qualitative statements about the technical shortcomings of the industry can be examined quantitatively and estimates can be made of the effects on the amount and type of labour requirements of the various changes that are canvassed from time to time. For example, generalized data like those in column (4) of Table 1 help in deciding two issues, which are: how far automatic looms should be used; and in what circumstances "bobbin changers," which relieve the weaver of the work of weft skewering and reshuttling, should be preferred to "shuttle changers," which relieve her of only weft reshuttling.

The picture of the work of various operatives and the interaction between operatives and machines is a very varied one; the following are a few examples:

The simplest system is that of a beamer with a single beaming frame. When the process requires attention the machine stops automatically; when the machine is going the operative is standing by. The extreme of complexity lies in the work of the weaver with non-automatic looms. She has usually four or six looms. Some of the work is done while the looms are going, some while they are stopped. For some causes the loom stops automatically, for others the weaver has to see the cause and stop the loom by hand, and she needs much time for general supervision, so that trouble can be anticipated. Table 1 shows one characteristic effect of the complexity of the weaver's job. When the weft breaks, or often when reshuttling is needed, the loom stops automatically, and since the weaver may be busy on another loom, the first one may have to wait for attention; on the average the time spent waiting for such attention is greater than that spent receiving attention. On the other hand, if a warp thread breaks, the loom continues working until the weaver stops it, and then she usually attends to it immediately, thus keeping low the time spent stopped awaiting attention for this cause.

When an operative has charge of more than one machine-unit, the problem arises as to the best number to place in each operative's charge. Broadly, if the number is large, there is a considerable synchronization of stoppages, machine utilization is relatively low and the utilization of the operative's time is high; and *vice versa* if the number is low; in the latter condition the machine sets the pace and machine speed largely determines the rate of output; in the former condition the rate of output is largely determined by the rate of working of the operative; under conditions between these extremes there is a balance. The best number of machine-units per operative depends on a mixture of technical, economic and psychological considerations. Thus, in ring spinning, where a large part of the operative's time is spent in feeding and attending to the machines while they are running, technical considerations are overriding, and the spindles per operative must be so arranged that there is very little waiting for the spinner's attention. In yarn winding, on the other hand, the individual spindle winds without supervision until attention is required, when it stops automatically and without harm remains stopped until the operative can attend to it; here economic considerations predominate, and since ordinary non-automatic winding machinery is inexpensive and labour is scarce, it is probably best to have an excess of spindles per operative so as to give the quickest winders full opportunity of producing their fastest. The conclusion will doubtless be different where expensive automatic machinery

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is used. In weaving on non-automatic looms there is an economic balance to be struck between machine and operative utilization with an upper limit of looms per weaver set by the facts that if the weaver has charge of too many looms, the supervision must be inadequate and cloth quality suffer, and that low machine utilization tends to have a depressing effect on the spirits of the operative.

In all the foregoing examples each operative works independently; in the cardroom of a spinning mill, on the other hand, the operatives in effect work in teams. The cardroom is arranged in "preparations," each containing a complete sequence of processes and machines (cards, draw-frames, and two or three types of speed frames); and the production of the machines and operatives in any one preparation is closely knit together since each operative can process only material that is passed to her. Here the arrangement must be such that the slower operatives can "keep up" with the requirements.

Clearly the problem of taking full account of costs in manpower and money, the quality of the product, the welfare of the operatives and the character of the process to determine in each case the best balance between machines and operatives is a complicated one. The results of our surveys provide a part, although only a part, of the necessary information. I think that the doing of the surveys and the cogitation over the results have also helped to analyse the factors in the problem. The theoretical calculation of the effects of the coincidence of machine stoppages raises certain problems in probability, to which we have given some attention—unfortunately without much profit. In order to postulate the problems in mathematical terms it is necessary to assume a simplicity and uniformity of behaviour of operatives and materials that is far from obtaining in practice; and even so the resulting mathematical problems have so far proved insoluble.

To reduce all the factors to one, and to confine attention to that, is to simplify the problem of labour deployment unduly. But one quantity emerges as being of first importance, and it is convenient to deal primarily with that, using it as an index of the most important conditions. That quantity is the percentage of the operative's time available for general supervision and relaxation. The surveys have shown what percentages are common for the various processes, and experience can suggest what percentages are desirable in any new organizations of labour. It may ultimately occur that agreements between employers and operatives will be as much concerned with this quantity (and associated standard timings for the main jobs) as with the traditional subjects of wages and hours.

The cotton industry is changing technically, and that requires changing organization of labour. Broadly, the system has been to assign each operative a definite number of machines, but this system is becoming outworn. It is criticized in its application to many sections of the industry as they are, and is obviously inadequate in times of technical change. Closely related to this is the question of wage payment, for the existing wage systems were designed many years ago, and even the 1945 proposals of the Evershed Commission on spinning wages make little or no provision for future changes. The need has been stated for systems of labour organization and wage payment, adapted to meet new technical conditions and flexible enough to meet changing conditions. The only basis that has been proposed for such systems is that known as "work measurement."

One can detect in the discussions of this subject two main approaches. The first is to refer the problem to time-study engineers who work out for each mill a special system suiting its conditions, the individual systems presumably conforming to some general pattern. The second is to revise the present "lists" which define for all mills the wage payments and (by implication) the labour organization, according to the methods of work measurement, deriving equations to express the fundamental factors that determine work load (frequencies and timings of jobs), and evaluating the parameters, some as standards for the whole industry and others by observation at the individual mills. For the first, it is urged that only in that way can sufficient flexibility be attained. The second approach gives some hope that a workable compromise can be struck between adaptability in the systems, and central control which representatives of the employers and workers seem to be loth to relinquish. The data for such revision obviously come from studies such as those I have described above, and we already have a good background of information for some sections of the industry.

Whether, in the various sections of the cotton industry, the tendency will be towards individual

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mill systems or revised "lists" having an industry-wide application, or whether some compromise will be evolved, remains to be seen. The question raises a statistical problem: what is the error with which different time-study engineers under different conditions evaluate the same job, compared with the effect of variations from mill to mill that cannot be taken into account in a "list"? It has not been proved as far as I know that the former errors are necessarily smaller than the latter. Here is a problem that may interest more industries than the cotton industry.

Although the Shirley Institute has been "pegging away" at mill surveys for many years, it is clear that only the fringe of the problems has been touched. During the earlier years those of us who did the work often felt that it was remote from reality, and even now we feel an occasional impatience at the slowness and reluctance with which the technical aspects of politico-technical problems are dealt with on technical lines. However, the situation is changing, as is shown by the emphasis the Cotton Working Party laid on a scientific approach to industrial problems and on the importance of operational research, and it is likely that the events of the next few years will justify those who controlled the research policy of the Shirley Institute in the difficult years and decreed that the survey work should go on, and the industrialists who, by allowing their mills to be surveyed, made it possible.

I should like to acknowledge the work of my colleagues in the liaison department of the Shirley Institute, who have been responsible for conducting most of the surveys.

Discussion on Mr. Tippett's Paper

Dr. E. C. Snow: I have read Mr. Tippett's paper with very great interest. The search for an explanation of the differences in productivity, which seem to emerge whenever figures of output per employee are compared, cannot get far without going right to the kernel of the matter as Mr. Tippett does. I have some distrust about deductions drawn from general data in productivity problems, as there is always the possibility of fallacies lurking in the statistics which can best be detected by those with inside knowledge of how they are collected and what they in fact actually mean.

I should like to illustrate the point by reference to figures of productivity in the footwear manufacturing industry. The indices of output in that industry are determined by dividing the total number of pairs of boots or shoes produced by the total number of workpeople employed. In some cases, however, the operatives turn out other goods than finished footwear, the production of these other goods being measured in the Census of Production Report only by value. Over the whole industry, in 1935, these goods represented 7 per cent. of the value of the whole of the products, but for some individual firms the percentage was, of course, much higher and for others lower. This vitiated comparison of the results of individual firms.

Another difficulty is that the amount of time spent on production in different firms, though not actually known, is, in fact, not the same for all firms. Outworkers and part-time workers are also engaged to some extent in the footwear industry, and these people count the same as full-time employees in calculating the index.

Another difficulty in comparing post-war figures with those of the Census of Production of 1935 is the fact that, owing to surplus employees in 1935, it was the practice in some firms to employ their operatives only three days a week, standing them off for three days a week, in order to spread employment and get the full benefit of the National Insurance scheme. This does not now occur. As one operative working six days will do much the same as two working three days, the comparison of indices is obviously affected.

Of the 600 or so boot manufacturers in this country it can truly be said that no two of them are alike in every respect. There is great variety in types of footwear produced, some specializing on men's, some on women's, some on slippers, while others spread their production over a number of classes. Female employment is general, but the extent of it varies from firm to firm, and I have rarely come across a case in which the statistical material is so heterogeneous. Some firms cut their own leather into soles, others buy some or all of them ready cut, and this naturally affects the number of workpeople they employ for a particular production in pairs of footwear. As is well known, some footwear is better than other footwear, and in producing better-class footwear as a rule more labour is employed; some footwear also is ornamented, involving additional labour.

A few figures can be given to indicate some of the points mentioned, but I would emphasize that they are for illustrative purposes *only*, indicating directions for further enquiry rather than proved results.

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(1) A sample of manufacturers turning out almost entirely men's footwear and cutting their own sole leather gave an index of production of 93 pairs per person per month. Another sample containing firms who bought cut soles in addition to cutting their own gave an index of 117. In the United States the practice of buying soles already cut is much more prevalent than it is here.

(2) A sample of firms making mainly women's footwear, but including in some cases children's footwear and slippers, gave an index of 78 as against the comparable figure of 117 for the men's.

(3) I have been interested in looking into the possibility of correlation between the production index and (*a*) the size of the firm, and (*b*) the proportion of female labour. The correlation coefficients are of interest merely as indicating directions for more detailed investigation, but may be worth quoting.

The correlation coefficient between the production index and the total number of employees for the three samples mentioned—that is, (i) men's with no cut soles, (ii) men's with cut soles, and (iii) women's—were $-\cdot30$, $-\cdot35$ and $-\cdot20$ respectively. These are not high, and no one would by itself be of particular significance. They do suggest, however, a negative association between size of firm and productivity in the footwear industry, though this may, of course, be due to size being correlated with some other factor, for instance, if the large firms turned out the best quality or the most ornamented footwear their productivity would appear relatively low.

The correlation coefficients for the same samples between productivity and percentage of females employed were $-\cdot50$, $-\cdot61$ and $-\cdot15$, suggesting a lower productivity of female labour. This again, however, may have some explanation, for example, if women are employed more on footwear of high quality than on footwear more rapidly turned out and of lower quality.

Although the statistical material perhaps hardly justifies going into the field of partial correlations, I might mention that the correction of the correlation coefficient between productivity and percentage of females for constant size of firm diminished the negative correlation by a small amount but not much. The corresponding correction of the correlation between size and productivity for a constant proportion of females reduced the negative correlations, however, to almost insignificance, suggesting that proportion of females is more important than size of firm in producing the negative correlation of each with productivity. There was in fact an appreciable positive correlation between size of firm and proportion of females employed, the figures for the three samples being $+\cdot21$, $+\cdot42$ and $+\cdot36$ respectively.

I would repeat that the figures mentioned are merely for the purpose of illustrating the various factors concerned in this particular problem. They suggest the lines for further investigation if any conclusions of a practical character are contemplated. It would be of interest to ascertain the correlation coefficient between the index of productivity and the profits shown by different firms. I should not be surprised if it turned out to be negative in the footwear industry, and I have been somewhat alarmed at suggestions which have been made that, under a paternal system of regulating industry, firms showing low indices of productivity should be examined with a view to their elimination from the industry. I am old-fashioned enough to prefer absence of profits as the best criterion for retirement of firms from an industry.

I have very much pleasure in proposing a vote of thanks to Mr. Tippett for his valuable contribution to this subject.

Dr. ROSTAS, in seconding the vote of thanks: there is double reason to be pleased with Mr. Tippett's paper—it is full of ideas and material for thought, and is in a way an account of the research work carried out in the Shirley Institute for over twenty years, and it makes us hope that at some future date we shall see the detailed results of these investigations.

Mr. Tippett read his paper at a very opportune moment. There is general agreement that efficiency is the key problem of our economic future, and that something must be done about increasing our efficiency. But one constantly feels that this something could be done so much better if we could know more how our efficiency is shaping at present and what are the factors which determine it. One cannot help looking with envy to the United States, not only because their efficiency is higher, but also because they have produced a fairly solid body of facts and information on the different aspects of their productivity, owing to the fact that research workers, the Government, industrialists, and trade unions have for long been conscious of the importance of this problem. The Bureau of Labor Statistics have, for example, recently started a Census of Productivity in the different United States industries. This has been possible because the American manufacturers are able and willing to carry out uniform man-hour accounting.

Mr. Tippett's paper was welcome to me because it indicated that my despair about our relative ignorance is perhaps not entirely justified, and because it demonstrated that in one of our basic industries that sort of work which one would like to see generally carried out is, in fact, applied.

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Two questions are of special interest in any productivity research—the measurement of productivity in all its aspects, and the analysis of factors affecting productivity.

In measuring productivity we obviously need some standard of performance as a yardstick, and this can be derived from comparisons. We make interspatial, intertemporal or interplant comparisons. It is necessary to emphasize that these are not alternative measurements; they measure the different aspects of productivity, and all three types of comparisons should be studied. The common characteristic in these measurements is that they all make a contribution to the second problem, the analysis of causes. We shall very likely get some way, if we know the causes of interspatial difference, towards accounting for intertemporal differences.

I entirely agree, however, with Mr. Tippett that interplant comparisons are the most promising field of research and the most likely field to enhance our knowledge. One of the main reasons for this has been mentioned by Mr. Tippett, namely, that the alterable factors can be studied more closely. Moreover, it is here that we get down to product instead of industry, and can also define more closely the process—the scope of process—to be studied: two difficulties which always arise using global figures based on Censuses of Production.

I also feel that once we succeed by interplant comparisons to establish standards of measurement of output per man for products and processes, we shall be able to utilize this knowledge to improve upon the cruder interspatial and intertemporal comparisons based on global figures.

It is obvious from Mr. Tippett's account that inter-firm analysis is very complicated, requiring time and patience as well as sound technical knowledge of the industry and willing co-operation from industrialists and workers. It appears to me that our research associations are admirably fitted to carry out this type of investigation, and no doubt they will get support from progressive firms. One knows that many of them are interested, are trying to develop their own standards of measurement, and will no doubt be pleased to relate their experience to the common yardstick.

There is one point, however, which I feel is important. As Mr. Tippett mentioned, these investigations mostly originated for some definite purpose—they were of the service investigation type. But one would like a much more systematic type of investigation relating to a fair sample of firms in each trade—rather more on the line of Shirley's abbreviated surveys—and to see these investigations carried to a point when information would be available to measure changes in output per man from time to time, and to relate standards of performance of bad and good firms to the average, as well as to factors which may determine the actual performance, such as size of plant, integration, standardization of product, type of equipment, lay-out, etc. I think I am right in believing that valuable information on such problems will arise out of Mr. Tippett's and the Shirley's investigations.

Such investigations are, of course, of primary interest to the industry. But most of the results will relate to factors which operate in all industries, and the lessons derived from such results will be equally important for all of them. One hopes, therefore, that these results will be made generally known to all research workers.

The vote of thanks was put to the meeting and carried unanimously.

Sir ROBERT PICKARD said that he wanted to congratulate his old friend on this paper. He had had a long road to travel, and twenty years ago he watched him start on this game—it had always been a game to him.

Mr. Tippett had the most uncanny flair for applying statistical research to practical problems. The speaker had been told that operational research—he thought that was the term used—was the invention during the war of a team of biologists, but Mr. Tippett had been at it for twenty-odd years. He thought that Mr. Tippett's success had been due to his habit of forgetting at times that he was a statistician. He had combined his statistical approach with a psychological approach, and this, in an old-fashioned industry with deeply ingrained methods, had been invaluable. One instance of this was his practical abolition of the stop-watch in walking round a mill.

The traditional complaints about bad material, work stoppages, and so on had led in the individual mill to the local trade union leaders having a talk with the local representatives of the Employers' Federation, both sides expressing their opinions and agreeing to differ and often to divide the difference. But Mr. Tippett had largely, he thought, inspired the system of fact-finding which was now permeating the industry, and was providing information and data on which exact opinions could be based. That psychological approach by a statistician had been one of the reasons for the successful permeation of his methods in the cotton industry.

There was one other point he would make, and that was that the observations in the mill had largely not been made by the author academically from the statistical point of view, but by the Shirley Institute liaison department. The liaison department was staffed with people who had had practical experience in a mill, and the observations by relatively junior persons of this type

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seemed to have evoked some sort of confidence among the operatives of the foreman type, who regarded the work not as "highfalutin" science, but as being done by people who, so to speak, belonged to themselves. The method and the technique that Mr. Tippett had described had largely eliminated not only the stop-watch, but the scientist walking round the mill and making his observations, and he was to be congratulated in that his methods were based upon what the liaison department had produced and which had the confidence of both sides of the industry.

Mr. A. W. SWAN said that it gave him great pleasure to contribute a little to this discussion, because the author had been very kind to his staff and himself in their efforts in the steel industry on the production side. He had acted as a kindly critic, and they had profited from his advice.

There was so much to talk about in the paper that he must confine himself to one or two points. The first was that, speaking as a production engineer with some experience of time study, he thought the author was a little unkind to the stop-watch, which he associated with exploitation and what not. This might be so in the minds of some people, but it need not be so. The stop-watch in proper hands need not mean any of these things. The method of snap reading the author had referred to—a very interesting method—did work obviously in the cotton industry where several machines are continuously doing similar jobs, and he dared say in other industries as well, such as tobacco; but in engineering it was very difficult to apply because of the diversity of work from machine to machine. Therefore he suggested that the author should modify his attitude to the stop-watch.

The remarks about the utility of statistics had interested him very much. That was a subject which must occupy the minds of those who were employing statistics in an industrial organization, to whom the economic argument was always present and rightly so. He and those associated with him had come to certain conclusions, which were roughly these, that they could justify themselves under certain headings. The first was that they were enabled by means of statistics to supply information either from existing or from new information, but quite often from existing information, and as a result of such information the management could mould policy in a way it had not been possible to do before. This was of very definite value, though not easily assessable in pounds, shillings and pence. Statistics could also save money directly or indirectly in the form of time or material. A statistical department must justify itself under one or more of these headings.

Often, as Mr. Tippett had said, in giving the results of statistics, they found themselves presenting things in definite numerical form which had been known qualitatively. They were not infrequently told, having carried out an investigation, "Oh, yes, we knew that; we have been doing that for some time." They now took the precaution, when starting an investigation, of asking those concerned what they hoped to find out.

With reference to Mr. Tippett's point that management might not be fully aware of what went on at lower levels, and that statistics could be useful in this respect, Mr. Swan mentioned that he had shown a certain mill manager that, whereas in the past he had been unable to provide concrete evidence in support of suggestions to his own higher management, statistical methods would now be able to either supply that evidence in definite numerical form, or to prove that he had no case.

Very often the secondary results were as important as the primary. Often useful results turned up which they did not expect. The economic side came into that also. In the investigation of cold rolling of a special type of steel strip, it was thought at first that it might be possible to instal quality control charts. The conclusion had been reached that it would be too expensive, that the margin would not justify the cost. But a secondary result emerged from the investigation which the management found very important, for it showed that the variability occurred mainly towards the end of the process, and therefore attention was focused on the final stages, and thus that statistical investigation brought about a useful secondary result.

Mr. G. F. TODD said that they were all aware of the many statements which had recently been made about the necessity of increasing industrial production per man-year, and, still more, production per man-hour, since the average man-hours worked per year was decreasing. Knowledge of actual production per man-hour (P.M.H.) was a necessary foundation for any improvement in productivity; otherwise they could not really know where these improvements were most likely to be found. He agreed with the author that the "overall" or "Census of Production" approach to P.M.H. took them only so far. Goods were made and services rendered by individual firms, and it was the P.M.H. of individual firms and of individual departments or products or processes of those individual firms in whose hands the future productivity of the nation lay. He wished, therefore, to compliment the author and the Shirley Institute on their efforts in grappling

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with this basic problem of determining the man-hours per unit product of actual products and actual departments of actual firms.

The author had something to say of "detailed surveys" and "abbreviated surveys" of man-hours per unit product, and it might be of interest to add something about a "permanent" system for measuring man-hours per unit product. He hoped it would not cause confusion if he used the abbreviation M.H.U.P. for man-hours per unit product rather than the author's O.H.P.—in fact, there seemed in these days to be so many different abbreviations for these concepts that a committee on standardization of terminology might soon be necessary.

By a "permanent" system he meant a system which recorded and allocated all man-hours worked each month and was capable of giving the M.H.U.P. of all products or groups of products month after month, analysed by department and process in precisely the same way as a costing system summarized and allocated costs each month. There were two great advantages if the M.H.U.P. recording system formed an integral part of the cost accounting system: firstly, it eliminated all duplication, the same basic records serving as far as possible both cost accounting and the productivity statistics, and secondly, it ensured that all hours whose costs were charged in the cost accounts were taken up in the productivity statistics. The overall accuracy of the productivity statistics was thereby assured. In fact, just as the cost accounts were tied in with the financial accounts, so the P.M.H. statistics were tied in with the cost accounts, and the three sets of records formed an economical, self-checking, and integrated accounting and statistical system. There was a further advantage of such a permanent system: he had found in practice that by comparison spot and test surveys of P.M.H. almost always over-estimated P.M.H., i.e. under-estimated M.H.U.P.—generally through insufficient allowance for non-productive or indirect time. This error was not present in permanent systems, since all the man-hours were automatically taken up. He did not suggest, of course, that the author's surveys suffered from this defect.

While he believed that the productivity statistics should be incorporated in the costing system, it had to be emphasized that productivity statistics and costing systems had quite different functions. The productivity statistics were solely concerned with getting the output; they paid no regard to costs. Whether or not increased P.M.H. would actually decrease or increase costs could be determined only from the cost accounts. To put it briefly, the productivity statistics would show the possibility of increasing P.M.H., while the cost accounts would show the profitability of doing so.

Of course, the manufacturer would also wish to be assured that if P.M.H. was increased it was not done at the expense of quality; or, if he was willing to sacrifice a small degree of quality, he would require to be assured that the loss did not exceed such degree as he was prepared to sacrifice. Measurements of quality were as important as those of productivity. It was here, of course, that quality control came in. In fact, productivity was quite a meeting-ground for accountants and statisticians.

Passing over the various technical problems involved in installing a system of permanent productivity statistics, which would be of interest mainly to accountants, he mentioned that the most satisfactory system seemed to be one which adopted the technique of standard costs, and fixed predetermined M.H.U.P. standards for the various jobs. Many difficulties were involved in setting up these standards, and the difficulties abounded particularly where the system covered more than one factory and it was desired to have the standards uniform as between factories. The great advantage of the system was that it enabled the actual P.M.H. of the various products or processes to be compared with the corresponding standard or target P.M.H.'s, and it permitted the actual output gained or lost by each department, sub-department, process or product by exceeding or falling short of standard to be ascertained. It made the results more meaningful if, for example, one could state that failure to reach the standard P.M.H. by one-tenth of a lb. per hour meant that the output of goods from the department or factory for a certain month was (say) 50,000 lbs. less than it should have been in view of the man-hours worked.

An integrated system of cost accounts and standardized productivity statistics enabled the variations in labour cost per unit of output to be analysed into variations in labour cost per man-hour (due, for example, to changes in wage rates, overtime, age or sex of workers) and to variations in P.M.H. (usually the main cause). In turn, P.M.H. could be analysed into differences between actual and standard P.M.H. and, if necessary, into the factors determining those differences; and in machine departments P.M.H. could also be analysed into machine speeds, machine efficiencies, numbers in machine crews, ratio of indirect to direct labour, etc.

The purpose of this type of analysis was to derive information of the extent to which the factory was getting the output it should, and how far this was affected by shortage of labour, inability to get new machinery, interruptions to supplies of materials, fuel and power cuts, and all the other obstacles that surrounded industrial management. But while different sections of

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industrial management were naturally interested in different sets of the figures produced by a permanent system of productivity statistics, he thought that, from the point of view of the statistician, the most interesting analysis was the comparison by process or department of the performance of different factories in producing comparable products.

There were, of course, many allowances to be made in comparing the productivity statistics of different factories, different firms, or for the same industries in different countries. But even after all allowances had been made there seemed to be a considerable spread in the M.H.U.P. of different factories producing similar goods. The author had found at least a two-to-one spread between mills producing similar yarns. He wished to inquire how far in the cotton industry these differences were systematic and how far random, for it was probable that both elements were present. For example, it was possible to construct control charts of the monthly M.H.U.P. variations of the departments of a particular factory, since, after adjusting the data to eliminate the effects of known systematic variations within the factory, it was probably legitimate to regard the residual variations as the fruit of a multitude of random causes normally distributed. But control charts of the M.H.U.P. of a group of factories could not be constructed because they contained variations due to systematic factors.

Further, he wondered whether the author had considered how far in the cotton industry the systematic elements of these variations could be identified with differences in (say) factory constants —size, lay-out, type of equipment, etc.—or with differences in worker-group consciousness of the type suggested by Elton Mayo or with other factors. He raised these questions because, given the age and sex distribution of workers and other long-term elements, it was the systematic factors which basically determined P.M.H. and governed the possibility of near-future increase, which determined how far the spread between the lowest and highest P.M.H. factories could be narrowed, and how far they must expect to find as a normal feature of British industry a variety which was as infinite as Cleopatra's, though possibly less pleasing.

Mr. EMERY said that he was not really competent to speak on this subject, but as it is said that an outsider sees most of the game, perhaps one or two observations from such a person might be of value. One point which struck him was the use of the word "efficiency." In engineering this word had a definite meaning, namely, the ratio of the output to the input of a machine, and he could visualize confusion occurring if the methods described in the paper were applied in an engineering concern. He suggested that another word should be used to describe what was called efficiency in the paper. One item entering into the efficiency (as used in the paper) was the ratio of the time that a machine was in working order to the total time under review. In his industry this ratio was termed the "availability," and he mentioned an item of interest which might not be immediately apparent, that the frequencies with which 1, 2, 3 . . . etc., machines were unavailable did not follow the binomial distribution, owing to greater efforts being made to return machines to service when availability was low, and to machines being deliberately taken out of commission for overhaul when general availability was high.

The paper appeared to take the individual operator as the unit on which to base the various calculations, and he wondered whether it would be better to start with the product and, instead of enquiring "How much product from one operator?" to ask, "How many operators for a certain amount of product?" The study could then be extended to cover other items besides manpower, such as coal and electricity, for example, and it might be found that differences in manpower between one producer and another coincided with compensating differences in power consumption.

Mr. TIPPETT, in replying to the discussion, said that he had only to thank various speakers for their comments and to say how greatly interested he had been in the discussion. He had been asked only one direct question: how far did the variations they had observed in their experience arise systematically or how far were they random? They were very much in the process of analysing all that now, and there was a mixture of technical variations which could be put down on paper, as well as all sorts of accidental things. It was a very complicated and mixed picture, but it was hoped one day to have all the results sorted out and to present a well analysed and complete survey.

Mr. TIPPETT subsequently wrote as follows:—

I think that if Mr. Emery refers to the paper again, he will see that we and Mr. Todd have used the unit of product as the base of the index we have christened O.H.P. The correct choice of the base is very important.

In the cotton industry the usage I have adopted of the word *efficiency* is well established and convenient. I hope that the engineers will not attempt to obtain an injunction against our continuing in that use of the word.

It is becoming increasingly clear that a very important group of causes of variations from

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mill to mill in labour productivity is described by the words *management* and *industrial psychology*. For many reasons different practices have grown up in different mills; only mental and moral inertia, fear and prejudice stand in the way of a considerable increase in productivity, that would accompany the elimination of all but the best practices. But the obstacle is a big one; the mental and moral problems of the cotton industry, like those of the country and the world, are more intractable than the technical problems.

As a result of the ballot taken during the meeting the candidates named below were elected Fellows of the Society:

John C. Bain, B.A.
George Alfred Barnard, M.A.
Benjamin Barnett, B.A.
John Wilson Boag.
Norman Henry Carrier.
John Chester.
David Roxbee Cox.
Stanley Cramp, B.A.
S. M. Dhume, Ph.D.
Sidney Gilbert Dibben.
Walter Arnold Dinsdale, B.Com.
Evelyn Maude Giles, B.Sc.
Bertram Haller.
Harold Gaunt Hudson.
Daniel Emanuel Ojumiri Johnson.
Herbert James Kenney.
Charles Hugh Kidman.
M. E. Linnell, M.A.
Maurice Milbourn.
John Morley.
Michael Philip Moss.
Charles Henry Nathan.
Charles Robert Oswin.
Pakki Bhaktavatsal Patnaik, M.A.
James Henry Perryman.
Neville Whiteoak Robinson.
John Douglas Robinson, A.I.A.
Frederick Aubrey Saville.
Keith Douglas Tocher, B.Sc.
Douglas Hammond Tovey, B.Sc.
George Wansbrough.
John Lawrence Whitwell.

Corporate Representatives.

Max Adler, *representing* Frank Murphy of London, Ltd.
Marjorie Deane, *representing* The Economist Newspaper.

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MISCELLANEA

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A LARGE-SAMPLE TEST FOR THE GOODNESS OF FIT OF AUTOREGRESSIVE SCHEMES

By M. H. QUENOUILLE
(Rothamsted Experimental Station)

BARTLETT (1946) has recently given formula for the variances and covariances of observed auto-correlation coefficients in terms of their theoretical values. These formula, which are independent of the underlying distribution error, have been used by Bartlett in their limiting forms to obtain a rough goodness-of-fit test for autoregressive schemes. The purpose of this paper is to demonstrate a more precise test for autoregressive schemes in large samples.

Bartlett's main formula for the covariance of two observed auto-correlations r_s and r_{s+t} in terms of the theoretical auto-correlations may be written—

$$\sigma^4 \operatorname{cov}(r_s, r_{s+t}) \sim \frac{1}{n} \sum_{\nu=-\infty}^{\infty} (\rho_\nu \rho_{\nu-t} + \rho_{\nu-s-t} \rho_{\nu+s} + 2\rho_s \rho_{s+t} \rho^2_\nu - 2\rho_s \rho_\nu \rho_{\nu-s-t} - 2\rho_{s+t} \rho_\nu \rho_{\nu-s}) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If we put $X_t = \sum_{\nu=-\infty}^{\infty} \rho_\nu \rho_{\nu-t}$ and

$$(1 + a_1 x + \ . \ . \ . \ + a_k x^k)^2 = \sum_{i=-\infty}^{\infty} A_i x^i$$

then by methods previously given (Quenouille, 1947*a*) it may be shown that

$$\left.\begin{aligned} \sum_{i=-\infty}^{\infty} A_i X_{t-i} &= 0 \qquad t > 0 \\ \text{and} \quad \sum_{i=-\infty}^{\infty} A_i \rho_{t-i} &= 0 \qquad t > k \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (2)$$

Using the formula (2) if we define $R_s = \sum_{i=-\infty}^{\infty} A_i r_{s-i}, \quad s = k+1, k+2, \ . \ . \ .$ then it is not difficult to see that

$$\begin{aligned} cov(r_s, R_t) &\sim 0 \qquad t > s \\ &\sim \frac{1}{n\sigma^4} \sum_{i=-\infty}^{\infty} A_i X_i, \quad t = s \end{aligned}$$

from which we get the following important result:

For n large, the forms R_s are independently and normally distributed about zero with variances $\sum_{-\infty}^{\infty} A_i X_i / n\sigma^4$. *Furthermore the forms $r_s - \rho_s \ s = 1, 2, \ . \ . \ . \ k$ are jointly distributed independent of the forms R_s.* Thus, if we use the equations $\rho_s = r_s$ to fit an autoregressive scheme, we can use the forms R_s to test the adequacy of the fit. For example, for the Markoff scheme $u_{n+1} = \rho u_n + \varepsilon_{n+1}$, we have $\rho_s = \rho_s \ X_t = \rho^t \frac{1+\rho^2}{1-\rho^2} + t\rho^t$ so that the forms $r_1 - \rho$, $R_s = r_s - 2\rho r_{s-1} + \rho^2 r_{s-2}$, $s = 2, 3, \ . \ . \ .$ are independently and normally distributed with variances $(1-\rho^2)/n$ and $(1-\rho^2)^2/n$. To test whether any scheme deviates significantly from a Markoff scheme, we might set $\rho = r_1$, and test the remaining degrees of freedom given by the forms R_s to magnitude,

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homogeneity, etc. Alternatively we can use the forms $r_1 - \rho_1$, and R_s ($s = 2 \ . \ . \ . \ q+1$) to obtain an optimum fit, and test the remaining q degrees of freedom together with the degrees of freedom given by R_s ($s = q+2 \ . \ . \ .$).

It is not difficult to see the forms R_s are related to the correlations r_i^1 of the ε_j, since

$$\begin{aligned} R_{k+j} &= \sum_i A_i \, r_{k+j-i} \\ &= \frac{\sum_i A_i \sum_l u_l \, u_{k+j+l-i}}{\Sigma u^2} \\ &\sim \frac{1}{\Sigma u^2} \Sigma\{u_l \, (\sum_{i=0}^{k} a_i \, \varepsilon_{k+l+j-i})\} \\ &\sim \frac{\Sigma \varepsilon^2}{\Sigma u^2} \sum_{l=0}^{\infty} B_l \, r_j^1{}_{-l} \qquad . \ . \ . \ . \ . \ (3) \end{aligned}$$

where

$$\frac{a_k + a_{k-1}t + \ . \ . \ . \ + a_0 t^k}{a_0 + a_1 t \ + \ . \ . \ . \ + a_k t^k} = \sum_{i=0}^{\infty} B_i t^i$$

From which, we deduce directly,

$$\begin{aligned} \sum_{i=0}^{\infty} B_i B_{i+l} &= 0 \qquad l \neq 0 \\ &= 1 \qquad l = 0 \qquad . \ . \ . \ . \ . \ . \ (4) \end{aligned}$$

Thus it appears that the R_s are moving averages of infinite extent of the r_i^1, so that each will provide a wider, as well as a simpler, test than the r_i^1.

From the formulae (3) and (4), it can be seen that

$$\text{var } R_s \sim \frac{1}{n} \left(\frac{\text{var } \varepsilon}{\text{var } u} \right)^2, \qquad s > 0 \qquad . \ . \ . \ . \ . \ (5)$$

A similar application confirms that R_s and R_t are uncorrelated. Thus, if we wish to test the legitimacy of assuming an autoregressive scheme $u_{n+2} + au_{n+1} + bu_n = \varepsilon_{n+2}$, we can use the estimates

$$a = -\frac{r_1(1-r_2)}{1-r_1^2}, \ b = \frac{1-r_2}{1-r_1^2} - 1 \text{ and test that}$$

$$r_{s+2} + 2a \, r_{s+1} + (a^2 + 2b) r_s + 2abr_{s-1} + b^2 r_{s-2} = R_s^1, \ s = 1, 2, \ . \ . \ .$$

are distributed with mean zero, and variance $\frac{1}{n} \left[\frac{(1-b)\{(1+b)^2 - a^2\}}{1+b} \right]^2$. This approximation can be improved still further by the use of $n-s$ instead of n.

To illustrate the method we shall consider firstly artificial series, for which a and b are known, and secondly series experienced in practice, for which a and b have been calculated. The adequacy of the usual methods of fitting an autoregressive scheme and its suitability for the representation of practical results will not be discussed here, but a discussion of these problems will be given elsewhere (Quenouille and Orcutt, 1947*b*).

Kendall (1946) has calculated auto-correlations of

(i) 480 terms of $u_{n+2} - 1{\cdot}1 \, u_{n+1} + 0{\cdot}5 \, u_n = \varepsilon_{n+2}$
(ii) 240 terms of $u_{n+2} - 1{\cdot}2 \, u_{n+1} + 0{\cdot}4 \, u_n = \varepsilon_{n+2}$
(iii) 240 terms of $u_{n+2} - 1{\cdot}1 \, u_{n+1} + 0{\cdot}8 \, u_n = \varepsilon_{n+2}$
(iv) 240 terms of $u_{n+2} + 1{\cdot}0 \, u_{n+1} + 0{\cdot}5 \, u_n = \varepsilon_{n+2}$

where the ε_n is a randomly-chosen number between -49 and $+49$. The values of $R_s{}^1$ together with the corresponding values of $\chi^2_{(1)}$ and $\Sigma\chi^2_{(1)}$ for each of the four series are given in Table 1.

It is seen that the values of $\Sigma\chi^2_{(1)}$ behave according to theory, the total for 90 degrees of freedom being 85·868. The values of $\chi^2_{(1)}$ can be compared with its distribution. This is done in Table 2. The expected number in each class is nine, so that the observed results again conform to theory.

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TABLE 1.—*Values of* R_s^1, $\chi^2_{(1)}$, *and* $\Sigma\chi^2_{(1)}$ *for Kendall's Artificial Series.*

Series i

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	·02412	2·319	2·319	16	−·00341	0·045	13·363
2	·00417	0·068	2·387	17	−·00305	0·036	13·399
3	·01979	1·558	3·945	18	·00687	0·181	13·580
4	−·00812	0·261	4·206	19	·01558	0·931	14·511
5	−·00013	0·000	4·206	20	−·00955	0·349	14·860
6	·02026	1·619	5·825	21	−·01610	0·990	15·850
7	−·02247	1·987	7·812	22	·00604	0·139	15·989
8	−·02903	3·310	11·122	23	−·01464	0·815	16·804
9	−·01047	0·430	11·552	24	−·02046	1·589	18·393
10	−·01226	0·588	12·140	25	−·00996	0·376	18·769
11	·00747	0·218	12·358	26	−·02064	1·610	20·379
12	·01345	0·704	13·062	27	−·00083	0·003	20·382
13	−·00573	0·128	13·190	28	·00079	0·002	20·384
14	−·00517	0·104	13·294	29	·00224	0·019	20·403
15	·00249	0·024	13·318	30	·00895	0·300	20·703

Series ii

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	−·02440	2·865	2·865	11	−·00500	0·115	14·012
2	−·01156	0·640	3·505	12	−·03040	4·243	18·255
3	−·01056	0·532	4·037	13	·00912	0·380	18·635
4	·02704	3·474	7·511	14	−·02896	3·816	22·451
5	−·02398	2·721	10·232	15	·00792	0·284	22·735
6	−·00040	0·001	10·233	16	·00624	0·176	22·911
7	·01992	1·862	12·095	17	·00068	0·002	22·913
8	−·01924	1·730	13·825	18	·01600	1·145	24·058
9	·00320	0·048	13·873	19	·01132	0·570	24·628
10	·00228	0·024	13·897	20	·01204	0·642	25·270

Series iii

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	·01133	0·605	0·605	11	·00247	0·027	13·919
2	·00773	0·280	0·885	12	·03281	4·824	18·743
3	·00243	0·028	0·913	13	−·01769	1·396	20·139
4	−·01192	0·659	1·572	14	·02389	2·535	22·674
5	−·01941	1·740	3·312	15	·01053	0·490	23·164
6	·03032	4·228	7·540	16	·00415	0·076	23·240
7	·00178	0·015	7·555	17	·00347	0·053	23·293
8	−·02385	2·594	10·149	18	·02687	3·151	26·444
9	·00885	0·356	10·505	19	−·00180	0·014	26·458
10	·02737	3·387	13·892	20	·01367	0·808	27·266

Series iv

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	·02900	1·158	1·158	11	·01900	0·476	9·362
2	·02000	0·548	1·706	12	−·03725	1·822	11·184
3	·00000	0·000	1·706	13	−·01225	0·196	11·380
4	−·04150	2·341	4·047	14	·00200	0·005	11·385
5	·00000	0·000	4·047	15	−·02350	0·716	12·101
6	−·05050	3·437	7·484	16	·00550	0·039	12·140
7	·03125	1·311	8·795	17	−·00575	0·043	12·183
8	·00025	0·000	8·795	18	−·01025	0·134	12·317
9	·00725	0·070	8·865	19	·01375	0·241	12·558
10	·00400	0·021	8·886	20	·00750	0·071	12·629

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TABLE 2.—*Observed Distribution of* $\chi^2_{(1)}$

P	*Number observed.*
0·0–0·1	11
0·1–0·2	12
0·2–0·3	9
0·3–0·4	6
0·4–0·5	8
0·5–0·6	11
0·6–0·7	5
0·7–0·8	8
0·8–0·9	9
0·9–1·0	11
	90

Before testing series which have been observed in practice, we shall be faced with the problem of superposed variation. If, in fact, a superposed variation, η_i, exists, then we shall observe a quantity $u_i + \eta_i$, and

$$\text{var } R_s \sim \frac{1}{n}\left(\frac{\text{var } \varepsilon}{\text{var } u + \text{var } \eta}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Thus significant differences between proposed and existing autoregressive schemes will tend to be obscured by superposed variation. This difficulty can be overcome if we observe from equation (3) that such differences will, in general, yield significant values of R_s only for s small, while for s large, R_s will have a variance given by (6). It will therefore be possible to list the values of R_s for s large to indicate the presence of superposed variation, while the adequacy of the fitted autoregressive scheme can be tested by a comparison of the values of R_s for s small and for s large. In carrying out this latter test, we must remember that our choice of what constitutes a large or small value of s will necessitate using a higher level of significance than usual. Thus the choice of the first eight values of series i and the first seven values of series iv to be tested against the other values given in Table 1, indicates a significant superposed variation and a significant deviation in the autoregressive equation at the 5% level. These spurious effects arise from a choice of a low level of significance, in fact, the next ten values of $\chi^2_{(1)}$ for series i total 7·2038, while the corresponding total for the next five values of series iv is 8·5638.

If we decide that a superposed variation is present, then we will require fresh estimates of a and b together with an estimate of $\frac{\text{var } \eta}{\text{var } u}$. These may be obtained in several ways : we may minimize the χ^2 obtained from R_s, $s = 1 \ . \ . \ . \ q$, or we may use the equations $\rho_s = r_s$. This latter method will be equivalent to choosing $q = k + 1$. Thus, for example, for the linear autoregressive scheme $u_{n+2} + au_{n+1} + bu_n = \varepsilon_{n+2}$, if we put $\frac{\text{var } \eta}{\text{var } u} = c$, we have

$$-\frac{a}{1+b} = r_1(1+c)$$

$$\frac{a^2}{1+b} - b = r_2(1+c)$$

$$-\frac{a^3}{1+b} + ab + \frac{ab}{1+b} = r_3(1+c).$$

The solution of these equations gives

$$a^2\frac{r_1^2 - r_2^2}{r_1 - r_3} + 2ar_2 + r_3 = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$b = -\frac{ar_2 + r_3}{r_1} \quad . \quad . \quad . \quad . \quad (8)$$

$$c = -\frac{a}{r_1 - r_3 - ar_2} - 1 \quad . \quad . \quad (9)$$

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where a is chosen from equation (7) so that c will be positive. This method of estimating a, b and c will not be the most efficient, and other methods are possible. Thus, for example, we might estimate a and b from

$$r_3 + ar_2 + br_1 = 0$$
$$r_4 + ar_3 + br_2 = 0$$

and these estimates will be independent of superposed variation.

We shall then have

$$\text{var } R_s \sim \frac{1}{n(1+c)^2}\left[\frac{(1-b)\{(1+b)^2 - a^2\}}{1+b}\right]^2 \quad . \quad . \quad . \quad (10)$$

provided that we replace $r_o = 1$ by $(1+c)^{-1}$ in R_s.

If we had treated this scheme as if no superposed error were present, we should have estimated

$$\text{var } R_s \sim \frac{1}{n(1+c)^2}\left[\frac{(1-b)\{(1+b)^2 - a^2\}}{1+b} + c\left((1-b) + \frac{(1+b)(1+c+2b+bc)\{(1+b+c)(1+b) - a^2\}}{(1+b)^2(1+c)^2 - a^2}\right)\right]^2 \quad . \quad . \quad (11)$$

$$\sim \frac{(1+\Delta)^2}{n(1+c)^2}\left[\frac{(1-b)\{(1+b)^2 - a^2\}}{1+b}\right] \qquad \text{for } c \text{ small}$$

where $\Delta = \dfrac{2(1+b)(1-b^3)}{(1-b)^2\{(1+b)^2 - a^2\}}$

Therefore the detection of any superposed variation will depend upon the value of $(1+\Delta)^2$. Thus, for example, in Kendall's series (i), we have

$(1+\Delta)^2 = (1 + 10{\cdot}1c)^2 = \left(1 + 29{\cdot}1\dfrac{\text{var } \eta}{\text{var } \varepsilon}\right)^2$, so that we should be able to detect easily a superposed variation of 5%.

If we multiply each of the coefficients of Kendall's series 1 by 0·9 this will roughly correspond to a superposed variation of 4%. We can fit an autoregressive scheme using the first two coefficients, giving $a = -0{\cdot}8554$, $b = 0{\cdot}2662$. The values of R_s^1, $\chi^2_{(1)}$ and $\Sigma\chi^2_{(1)}$ are given in Table 3.

TABLE 3.—*Values of* R_s^1, $\chi^2_{(1)}$ *and* $\Sigma\chi^2_{(1)}$ *for Kendall's Series i with Theoretical Damping*

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	−·04923	4·550	4·550	11	·00678	0·084	10·150
2	·00556	0·058	4·608	12	·01372	0·345	10·495
3	·01694	0·536	5·144	13	·01340	0·329	10·824
4	·00045	0·000	5·144	14	·00150	0·004	10·828
5	−·00249	0·011	5·155	15	−·00160	0·005	10·833
6	·01390	0·359	5·514	16	−·00799	0·116	10·949
7	·01463	0·397	5·911	17	−·00805	0·117	11·066
8	−·03471	2·229	8·140	18	·00245	0·011	11·077
9	−·02625	1·272	9·412	19	·01706	0·526	11·603
10	−·01884	0·654	10·066	20	·00127	0·003	11·606

If the first ten degrees of freedom from this table are tested against the second ten, the result is significant at the 1 per cent. level, while the latter ten degrees of freedom are 99 per cent. significant. Thus it appears that the estimates of a and b are biased towards zero, probably as a result of superposed variation. This conclusion is strengthened by the large value of R_1^1, due to the fact that $r_o = 1$ cannot be altered by superposed variation. For practical series, we use Beveridge's (1921) series of wheat-price index, and Kendall's (1943) series of wheat, barley and oats prices. Autoregressive schemes have been fitted to these series using the first two autocorrelations, and the fitted schemes are tested in Table 4.

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TABLE 4.—*Values of* R_s^1, $\chi^2_{(1)}$ *and* $\Sigma\chi^2_{(1)}$ *for Practical Series*

Beveridge's wheat-price index

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	·02395	0·554	0·554	11	·02011	0·380	20·279*
2	—·02230	0·479	1·033	12	·04181	1·639	21·918*
3	—·02662	0·681	1·714	13	·02435	0·554	22·472*
4	—·07800	5·831	7·545	14	·06797	4·307	26·779*
5	—·07122	4·848	12·393*	15	—·02899	0·781	27·560*
6	—·07984	6·076	18·469†	16	—·01629	0·246	27·806*
7	·00118	0·001	18·470*	17	—·01360	0·171	27·977*
8	—·00760	0·055	18·525*	18	·01619	0·242	28·219
9	—·02433	0·560	19·085*	19	·00738	0·050	28·269
10	—·02939	0·814	19·899*	20	·06872	4·328	33·597*

Kendall's wheat prices

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	—·02173	0·110	0·110	11	—·09806	1·884	15·333
2	—·14697	4·936	5·046	12	·00078	0·000	15·333
3	—·04400	0·435	5·481	13	—·15599	4·590	19·923
4	—·12796	3·623	9·104	14	—·07101	0·933	20·856
5	·01950	0·083	9·187	15	·10241	1·902	22·758
6	·12078	3·122	12·309	16	—·00230	0·001	22·759
7	·03703	0·288	12·597	17	·09470	1·562	24·321
8	·01337	0·037	12·634	18	·04095	0·286	24·607
9	·04921	0·492	13·126	19	—·04107	0·282	24·889
10	—·03990	0·323	13·449	20	—·01493	0·036	24·925

Kendall's barley prices

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	—·20886	8·019	8·019†	11	·00340	0·002	21·142*
2	—·01528	0·042	8·061*	12	·01367	0·028	21·170*
3	—·01587	0·045	8·106*	13	·00017	0·000	21·170
4	—·02523	0·112	8·218	14	·01247	0·023	21·193
5	—·24002	9·928	18·146†	15	·09616	1·328	22·521
6	·05606	0·533	18·679†	16	·06852	0·661	23·182
7	·06002	0·600	19·279†	17	—·01177	0·019	23·201
8	—·05828	0·556	19·835*	18	—·01926	0·050	23·251
9	—·07066	0·803	20·638*	19	—·01130	0·017	23·268
10	—·05634	0·502	21·140*	20	—·05253	0·357	23·625

Kendall's oats prices

s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$	s	R_s^1	$\chi^2_{(1)}$	$\Sigma\chi^2_{(1)}$
1	—·15114	4·023	4·023*	11	—·09810	1·415	20·882*
2	—·20087	6·995	11·018†	12	·02960	0·128	21·010
3	·06577	0·738	11·756†	13	—·03101	0·138	21·148
4	—·15404	3·983	15·739†	14	·03699	0·192	21·340
5	·11821	2·307	18·046†	15	·12130	2·024	23·364
6	·07870	1·006	19·052†	16	·00706	0·007	23·371
7	—·03137	0·154	19·206†	17	—·00608	0·005	23·376
8	·01818	0·052	19·258*	18	·02389	0·074	23·450
9	·00783	0·009	19·267*	19	—·07951	0·800	24·250
10	—·03633	0·200	19·467*	20	—·05293	0·347	24·597

* Denotes 5 per cent. significance. † Denotes 1 per cent. significance.

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It appears that, of the four series, only Kendall's wheat prices are fitted adequately by the chosen autoregressive scheme. That the other series differ from the fitted autoregressive schemes is shown by the high values of $\Sigma\chi^2_{(1)}$ and the correlation between successive values of R_s^1. For Kendall's wheat and oats prices, the estimates of a and b appear to be biased towards zero, and there is a strong suggestion of superposed variation, since the initial values are high, and $\chi^2_{(1)}$ rapidly decreases to a mean value of less than one.

It must be remembered that the above examples test particular autoregressive schemes, and not the most general autoregressive scheme. Thus it may be possible to a better fit by another second-order autoregressive scheme, or by a scheme of a higher order. This presents primarily a problem of fitting, which is being made the subject of another paper (Quenouille and Orcutt, 1947*b*).

Summary

A test has been proposed for the adequacy of representation of fitted autoregressive schemes, when the number of observations is large. This test has been found to work satisfactorily on artificial series. It has been shown how superposed variation can be detected by this method, and series experienced in practice have been used to demonstrate the test.

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A Review of some Recent Work on Discontinuous Markoff Processes with Applications to Biology, Physics and Actuarial Science

By David G. Kendall (Magdalen College, Oxford)

On Random Processes and their Application to Sickness and Accident Statistics. By O. Lundberg. Almqvist and Wiksells, Uppsala, 1940. $9\frac{1}{4}''$ by $6''$. vii + 172 pages.

On the Theory of Stochastic Processes and their Application to the Theory of Cosmic Radiation. By N. Arley. G. E. C. Gads, Copenhagen, 1943. $9\frac{3}{4}''$ by $6''$. 240 pages.

These two fascinating volumes, which it is convenient to review together, can be warmly recommended to all who may be interested in the subjects covered by their titles, and it is very much to be hoped that they will find a wider circle of readers. The stochastic processes discussed by these authors are admittedly of a very special type, but it is one which has already found several intriguing applications, and there is every indication that many others will suggest themselves as soon as the theory becomes more widely known. The first general discussion was given by A. Kolmogoroff (**11**) in 1931 and the theory then constructed (which was further developed by W. Feller (**4**) five years later) becomes relevant whenever the state of a system can be described by the value of a random time-dependent variable $X(t)$ possessing the following property: *let the value of $X(t_0)$ be known; then if $t_1 > t_0$, the conditional distribution of the random variable $X(t_1)$ is in no way affected if the value of $X(t)$ is also given for any $t < t_0$.* The implications of this are best studied in relation to an actual example: if a process of this type is to be employed to describe the growth of an (idealized) population the quantity $X(t)$ can be identified with the number of individuals at time t, and the description will then be adequate if one is content to assume* that the effects of reproduction and mortality proceed independently for each individual at rates which depend at most on the time t and on the instantaneous population size $X(t)$. In particular, such indices of past history as the age-structure of the population cannot be allowed to influence the future development of the process, although this situation can be remedied to some extent by employing a multivariate process in which each component of the *vector* variable $\mathbf{X}(t)$ represents the number of individuals in one of several age-groups.†

Processes possessing the property italicized above were said by Kolmogoroff to be "stochastisch definit," but the shorter phrase "a Markoff process" is now gaining currency‡ and is historically appropriate because of Markoff's work on random *sequences* X_r possessing the same property.§ In most of the applications the assumption of the Markoff property corresponds to an over-simplification of the facts, but it is one which is often acceptable in a first attack on the problem. A comparative study of the solutions to some simple problem with and without the "Markoff" assumption is likely to prove generally instructive; such an opportunity is now offered by the simplest problems of population growth.

Both Arley and Lundberg in their original contributions to the theory pay most attention to the *discontinuous* Markoff processes of which the "birth-and-death" process just mentioned is an example. Their characteristic property is that as the time progresses the variable $X(t)$ changes its value in a series of abrupt jumps (usually the range of values of $X(t)$ is discrete, as here, but this is, of course, not necessary). Such processes are to be distinguished from those of the continuous type met with, for example, in the theory of diffusion in which (crudely speaking) small changes in the value of $X(t)$ occur incessantly. Processes of either type are covered by the general theory, of which Lundberg gives an admirable summary in his second chapter.

* A more detailed analysis of the assumptions in this case will be found in my paper (**9**).

† A discussion of this problem is given by M. S. Bartlett (**2**).

‡ This, for example, is the terminology adopted by H. Cramér in his recent survey, "Problems in probability theory" (*Annals of Mathematical Statistics*, **18** (1947), 165–193, esp. 184–5).

§ See, e.g., M. Fréchet (**8**).

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To proceed to a detailed review: Lundberg gives an exhaustive account of the so-called "elementary" processes* in which the variate $X(t)$ in any element of time dt must either remain unchanged or must undergo the transition $n \to n+1$. The structure of the process can then be described in one of several ways; in the first of these it is supposed that the probability of the transition $n \to n+1$ is $p_n(t)dt + o(dt)$, and a knowledge of the *intensities* $\{p_n(t)\}$ then determines the form of the process. From another point of view the process can be defined by giving the *transition probabilities*

$$P\begin{pmatrix} m, & t \\ n, & s \end{pmatrix},$$

where $X(s) = n$ is the initial state and $X(t) = m$ is the final state. These must satisfy the Chapman-Kolmogoroff relation,

$$P\begin{pmatrix} m, & t \\ n, & s \end{pmatrix} = \sum_{r=n}^{m} P\begin{pmatrix} m, & t \\ r, & u \end{pmatrix} P\begin{pmatrix} r, & u \\ n, & s \end{pmatrix} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

for any $s < u < t$. For an "elementary" process the intensities are related to the transition probabilities by the infinite set of differential-difference equations

$$\frac{d}{dt} P(m, t) = -p_m(t) P(m, t) + p_{m-1}(t) P(m-1, t) \quad . \quad . \quad . \quad (2)$$

(where the dependence of $P(m, t)$ on n and s is to be understood), and a recursive solution to these equations can very readily be found. The "elementary" processes therefore permit a detailed investigation which would hardly be possible in the general case, and Lundberg has explored their properties very thoroughly; in particular he has succeeded in proving for them an extension of a theorem of Feller. One of the central problems of the mathematical theory is to determine from the form of the intensities $\{p_n(t)\}$ whether the equations possess a solution such that the law of total probability,

$$\sum_{(m)} P(m, t) = 1, \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

is obeyed for all t. (If this fails, it implies that the variable $X(t)$ has a positive probability of reaching "infinity" in a finite time.) Feller showed that the uniform boundedness of the $\{p_n(t)\}$ in every finite time-interval is sufficient for (3), but unfortunately this excludes many of the most interesting examples. Later (**5**) he pointed out that the divergence of the series $\Sigma 1/p_n(t)$ might be relevant, and now Lundberg for his "elementary" processes has gone far towards reaching the final truth in this matter.†

Among the "elementary" processes two classes are of special interest; the first of these, the class of *temporally homogeneous* processes, is characterized by the fact that the intensities $\{p_n(t)\}$ are constants, $\{p_n\}$. Lundberg gives a very useful study of its properties, and proves that the divergence of the series $\Sigma 1/p_n$ is necessary and sufficient for the positive‡ constants $\{p_n\}$ to define a process for which (3) is true for all t. (This theorem had already been stated without proof by Feller (**5**).)

The second important class of "elementary" processes consists of those of the *compound Poisson* type, and here again Lundberg's discussion is likely to be of permanent value. He shows how these processes can be introduced from two different standpoints, and establishes the equivalence of the two definitions with the aid of the theory of completely monotonic functions.§ A

* This may not prove to be the most convenient nomenclature, and the alternative name "an escalator process" may be considered more suitable.

† A still more complete account of the $\Sigma 1/p_n$ criterion will be found in Feller (**6**), where the purely discontinuous Markoff process is discussed in great generality.

‡ There are fairly obvious modifications of this result if some of the p_n are zero. If *all but a finite number* are zero the number of possible states is finite and no further condition is required.

§ For the theory of completely monotonic functions see D. V. Widder (**13**).

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completely monotonic function $P(t)$ defined in $t > 0$ has the property that its kth derivative has the sign of $(-1)^k$, for all $k = 0, 1, 2, \ldots$; a theorem of S. Bernstein then asserts that

$$P(t) = \int_0^\infty e^{-tx}\, d\,U(x), \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where $U(x)$ (if $P(0+) = 1$) is a distribution function over $(0, \infty)$. This condition is both necessary and sufficient. Lundberg shows that the equations

$$p_n(t) = -\frac{P^{(n+1)}(t)}{P^{(n)}(t)} \quad (t > 0) \quad . \quad . \quad . \quad . \quad . \quad (5)$$

define the intensities of an "elementary" process if and only if $P(t)$ is completely monotonic and $P(0+) = 1$. The intensities then satisfy the characteristic differential-difference relation

$$p_{n+1}(t) = p_n(t) - \frac{p_n'(t)}{p_n(t)}, \quad . \quad . \quad . \quad . \quad . \quad (6)$$

and the (absolute) transition probabilities are given by

$$P\begin{pmatrix} m, t \\ 0, 0 \end{pmatrix} = \int_0^\infty \frac{(tx)^m}{m!}\, e^{-tx}\, d\,U(x), \quad . \quad . \quad . \quad . \quad . \quad (7)$$

the law of total probability (3) being obeyed.

This formula for the (absolute) transition probability displays at once the second interpretation of the compound Poisson process (and the reason for its name): it can be thought of as a pure Poisson process, for which

$$P\begin{pmatrix} m, t \\ 0, 0 \end{pmatrix} = \frac{(tx)^m}{m!}\, e^{-tx}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

when the "risk" x (so-called because in Lundberg's applications it represents the mean number of accidents per unit time) is itself a random variable with a distribution function $U(x)$. Thus the compound process may be considered to have been drawn at random from a super-population of pure Poisson processes whose individual risk-constants follow this law of distribution. Lundberg brings out this duality with great clarity, and draws special and timely attention to its implications in the most important practical example, the Pólya process,* for which the (absolute) transition-probability distribution $P(m, t)$ is of Negative Binomial form. The intensities are then

$$p_n(t) = \frac{1 + bn}{1 + bt} \quad (b > 0), \quad . \quad . \quad . \quad . \quad . \quad (9)$$

and from this standpoint the process was introduced by G. Pólya (**12**) and F. Eggenberger (3) to exemplify the action of *contagion* (the latter author discussing the process in relation to small-pox statistics). On the other hand, the Pólya process can be thought of as a pure Poisson process whose unknown risk-constant is distributed in the modified χ^2-distribution

$$d\,U(x) = \frac{a^a}{\Gamma(a)}\, e^{-ax}\, x^{a-1}\, dx \quad (0 < x < \infty, ab = 1). \quad . \quad . \quad . \quad (10)$$

This is, of course, the route followed by M. Greenwood, E. Newbold and G. U. Yule in well-known papers published in this *Journal* in 1920 and 1927.

* For a further discussion of the dual character of the Pólya negative-binomial process, see also Feller (7). He points out very clearly the difficulties of discriminating between "contagion" and heterogeneity.

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The last mathematical chapter in Lundberg's book is concerned with the process generated in the following manner: the variate $X(t)$ can now assume any real value; its transitions take place at instants determined by a compound Poisson process, but the amount of each jump (y) is an independent variable following a distribution function $V(y)$. If $X(t) = 0$ when $t = 0$, the distribution function of $X(t)$ at a later time t is then

$$\sum_{m=0}^{\infty} P\begin{pmatrix} m, t \\ 0, 0 \end{pmatrix} V_m(X), \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

where $V_m(y)$ is the mth "convolution" of $V(y)$ with itself. The application which Lundberg has in mind is the following: the instantaneous jumps determined by the compound Poisson process are instances of sickness or accident, all referring to a particular policy-holder, while y is the amount of benefit*; $X(t)$ is then the cumulative benefit associated with that particular insurance policy. No use is made of this, however, in the chapter of practical applications with which the work concludes.

To pass now to the practical applications† of the theory made by Lundberg; these are reported on in the last chapter, which can, with the introduction, be read very largely in isolation from the rest of the work. The author considers the records of "small" insurance against sickness and accident supplied to him by the company Sjukförsäkrings-A. B. Eir, which guarantees a small weekly benefit, up to age 60 or 65, for as long as complete incapacity lasts. The number of policies considered is of the order of 1,000 and the mean number of claims per policy is of the order of 0·3 – 0·5 per year. It is shown that the numbers of policies making 0, 1, 2, . . . claims over a given period of years can to a good approximation be represented by the terms in a negative-binomial series, the deviations (when judged by the χ^2-test) being non-significant. This confirms the experience of Newbold. It is also found that there is a distinct correlation between the numbers of claims on the same policy in two different periods, and that the total time of benefit during a period is, to a large extent, conditioned by the number of claims during a preceding period. The author considers that the heterogeneity of risk (which may to an important extent be a heterogeneity of "morality" risk) cannot readily be identified with a heterogeneity of recognizable individual characteristics, and that therefore it is best to calculate a corrected risk premium on the basis of an initial experience (say of two years) with each individual policy. This is the more necessary when (as in the present instance) the insurance is voluntary and non-cancellable. An attempt is therefore made to fit a compound Poisson process to the data, $X(t)$ for a particular policy being the number of claims since the commencement (the two sets of records used each relate to a batch of policies commenced at about the same date). A number of significance tests of great ingenuity are devised and applied to the data; the author would, I think, be the last to claim any finality for these, but they certainly suggest a new group of statistical problems which will no doubt receive much attention. On many counts the fitted compound Poisson process—which is eventually taken to be of the Pólya type—fails to pass the author's tests, but he has collected an impressive bulk of evidence to support his suggestion that none the less a Pólya process (with one modification) may afford an acceptable graduation of the data.

The modification depends on the fact that any of the processes considered may be generalized to admit of an arbitrary transformation of the time scale—for the compound Poisson process this means that the individual risks are allowed to vary in constant proportion to the *same* function of the time t. The appropriate interval of "operational" time can then be estimated by identifying it with the mean number of claims per policy in the corresponding interval of "actual" time.

If the applicability of the Pólya process were allowed, the corrected "natural" premium would be

$$S\,c\,T\left(\frac{1+bn}{1+bs}\right), \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

* It is apparently assumed here that the full benefit is paid *instantaneously*. Lundberg mentions another interpretation in which y is the duration of incapacity; this as it stands seems to involve some inconsistency.

† For an alternative treatment of his problem Lundberg refers to a recent monograph by J. Dubourdieu: *Théorie de l'Assurance-Maladie* (Paris, 1939).

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where c is the mean benefit time per claim, S the sum to be paid per unit of benefit time, T the duration of the policy, and n the number of claims made during the trial period of length s. The constant b, which measures the variance of the risk distribution, is to be estimated from an analysis of the company's experience over a number of years. Such an estimate for the insurance company Eir is given by Lundberg, but his analysis brings out a secular variation in the value of b which would certainly have to be taken into account.

Lundberg concludes by remarking that such a regrading of the premiums would on current insurance principles be justified only if the differing risks were actually present when the insurance was effected, and did not originate during the trial period. Because of the dual character of the Pólya distribution, and the possible confusion between contagion and heterogeneity, this point obviously requires rather close attention.

I have given a very detailed account of Lundberg's work, and if I appear to do less justice to that of Arley, this is because his field of application will probably be unfamiliar to most readers of this *Journal*, as indeed it is to me. It is, however, a satisfying tribute to the indivisibility of our subject that Arley's consideration of these problems of modern physics is of great relevance in another field with which most statisticians are more nearly concerned—the theory of population growth. Arley's work can in fact best be approached by first reading a most important and (in this country) little-known paper of Feller (**5**) on the application of Markoff processes to a series of population problems normally treated in a deterministic manner leading to exponential or logistic laws of growth.

When a single "particle" from the "soft" component of cosmic radiation is incident on a slab of material substance a multiplication of its effect is observed, and this "cascade shower" is believed to be generated in the following manner. An energetic photon travelling a distance dt in the material has a certain probability (asymptotically proportional to dt) of being absorbed and emitting a pair of particles consisting of a positive and a negative electron. Similarly an electron of either species on travelling a further distance dt has a chance (asymptotically proportional to dt) of losing some of its energy by emitting a photon. While at each stage the individual energies are degraded, it is clear that at least during its early history a cascade shower undergoes a progressive multiplication very similar to that of a growing population. In order to apply a Markoff process much simplification is necessary, but it is evidently possible to improve considerably on the original treatment of the subject, which was based on a pure Poisson process.

According to Arley, one of the first problems in the theory was the determination of the *mean* number of electrons produced in this way when a primary "particle" (electron or photon) is incident on a metal slab of given thickness. Only the number of *electrons* is required, because only these are detected. He sketches the deduction of this mean number by Bhabha and Heitler, and then points out that in practice it is not possible to neglect the *fluctuations* in the number of particles about its mean, especially because the experimental data (the Rossi curves) are only available in the form "percentage of showers containing (say) *at least two* electrons, as a function of the thickness of metal traversed." Hence the importance of determining the actual probability distribution: the chance that a primary particle of given nature and energy will produce a shower containing exactly 0, 1, 2, . . . secondary electrons on traversing a given thickness of metal. Unfortunately I found Arley's account of the experimental side of the work very hard to follow; he is clearly assuming more physical than mathematical knowledge on the part of the reader. In particular it was not easy to see how the various arrangements of Geiger-Müller counters in "coincidence-coupling" could lead to records capable of being directly related to the theoretical probability distributions. However, it is his method of obtaining the latter which is of interest to the statistician, for it is intimately related to parallel problems in the biological field.

Arley's first attempt to improve on earlier models makes use of a "birth-and-death" process which had already been discussed in its biological rôle by Feller (**5**). This is governed by the equations

$$\frac{d}{dt}P(m,t) = (m+1)\mu_0 P(m+1,t) + (m-1)\lambda_0 P(m-1,t) - m(\lambda_0+\mu_0)P(m,t) \quad (m \geqslant 1),$$

$$\frac{d}{dt}P(0,t) = \mu_0 P(1,t), \qquad (13)$$

$P(m, t)$ being the probability that the shower will contain exactly m particles after traversing a

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thickness t, while $\lambda_0 dt$ and $\mu_0 dt$ are respectively the probabilities that a member of the shower will, on traversing the element of thickness dt, reproduce itself, or be absorbed, respectively. In the biological interpretation t is the time, while λ_0 and μ_0 are the (constant) expected birth and death rates per unit of time per head of population, respectively. The corresponding deterministic model is thus described by the differential equation

$$\frac{dm}{dt} = (\lambda_0 - \mu_0)\, m, \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

with solution $m = m(0)\, e^{(\lambda_0 - \mu_0)t}$.

Next, he takes into account the gradual degradation of the energy per "particle" as greater thicknesses of material are traversed; in an earlier attempt he had approached this problem by removing particles from the calculations after they had taken part in a sufficient number of transformations to cause them to lose the greater part of their energy. This, of course, leads to a process which does not possess the Markoff property, and accordingly only a step-by-step solution was possible. In order to cast the process into a Markoff form it was necessary to introduce the energy degradation indirectly, by allowing the absorption (death) rate μ to increase with the thickness traversed (time elapsed); Arley therefore writes $\mu_1 t$ for μ, and the new process, no longer temporally homogeneous, is governed by a set of differential-difference equations of the same type as (13). This device leads immediately to a great improvement in the model, for with the (λ_0, μ_0) process the mean number of particles was

$$\overline{m}_t = e^{(\lambda_0 - \mu_0)\, t}, \quad \text{if } m_0 = 1, \quad . \quad . \quad . \quad . \quad . \quad (15)$$

while in Arley's $(\lambda_0, \mu_1 t)$ process it is given by the Gaussian function

$$\overline{m}_t = e^{\lambda_0 t - \frac{1}{2}\mu_1 t^2}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

in general agreement with observation—the mean size of the shower being greatest for a certain optimum thickness and then decaying to zero.

Finally he generalizes this model to admit particles of two species, each liable to absorption at a rate λ_0, followed by the production of a pair of particles *of the other kind*, and to a second kind of absorption, at an increasing rate $\mu_1 t$, in which no further particles are produced. This is, of course, a *bivariate* Markoff process, which must be described by a probability distribution of the form $P(m, m', t)$, where m and m' are the numbers of particles of each kind at the stage of development of the process indicated by the value t.

For all these processes Arley evaluates the mean and variance for the number of particles (and also, in the last model, the covariance of m and m'). Finally, in the absence of an exact formula for $P(m, m', t)$, he approximates to the true marginal distribution $P(m, t)$ for particles of the first kind (electrons) by fitting a Pólya (negative binomial) distribution, and checks the accuracy of this procedure by comparing the result with a step-by-step solution of the differential-difference equations for $P(m, m', t)$. The agreement is quite good, and enables Arley in his final chapters to use the fitted Pólya distribution in his theoretical determination of the form of the Rossi curves.

M. S. Bartlett (2) has recently pointed out that Arley's second model, leading to his $(\lambda_0, \mu_1 t)$ process, has an interesting interpretation in the language of epidemiology. In this, m_t is the number of infected-and-infectious cases of a disease at time t in a *large* population (so that the controlling effect of the number of susceptibles plays no appreciable part in determining the course of the epidemic). These cases are each supposed to infect others at a rate λ_0, and to recover (or otherwise cease to be counted in the total, m_t) at a steadily increasing rate $\mu_1 t$. The *expected* number of cases will then, as in Arley's model, be a Gaussian function of the time, and its "transient" form can be given an intuitive interpretation if one observes that cases of the disease arising during the later phases of the epidemic (when $\mu_1 t$ is relatively large) will recover so quickly that they will have little opportunity of furthering the spread of the infection. How far such a mechanism might be of real importance in epidemiology is uncertain, but in view of

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the near-Gaussian character of the epidemic curves actually observed* it would at least seem worth while re-examining the classical models of epidemic behaviour with the aid of the Markoff process technique.

I have left to the last an account of Arley's contributions to the mathematical theory because they play no part in his later applications, and his methods do not in fact yet appear to have proved their usefulness except in the demonstration of mathematically quite important uniqueness and existence theorems. He takes a much broader view than Lundberg, considering the most general discontinuous process of the Markoff type possessing a discrete set of states, and employing an elegant matrix notation. For example, in his terminology the fundamental differential-difference relation takes the form

$$\frac{\delta}{\delta t}\mathbf{P}\begin{pmatrix} t \\ s \end{pmatrix} = \mathbf{A}(t)\,\mathbf{P}\begin{pmatrix} t \\ s \end{pmatrix}, \qquad (17)$$

where the component (m, n) of the infinite matrix $\mathbf{P}$ denotes what we have called

$$P\begin{pmatrix} m, t \\ n, s \end{pmatrix},$$

while the matrix operator $\mathbf{A}$ determines the nature of the process. He gives a general account of differential equations of this form, and describes a number of wide classes of operators $\mathbf{A}$ such that the solution has the property

$$\sum_{(m)} P\begin{pmatrix} m, t \\ n, s \end{pmatrix} = 1.$$

His sufficient conditions for the validity of this law of total probability are wide enough to cover the processes later employed in the applications, and they include generalizations of the criteria of Feller and Lundberg mentioned above.

Arley's series and "product-integral" solutions of (17), though of great elegance and generality, are unfortunately of little value when a solution in closed form is desired; as Arley himself points out, they lead to cumbersome power-series in $(t - s)$ even when the process is the simple "birth-and-death" mechanism represented by (13). In this connexion it may be mentioned that a generating-function method apparently first introduced by C. Palm has met with more success. His solution to the equations (13) for the simplest "birth-and-death" process has been quoted by Arley and V. Borchsenius (**1**), but an account of his method does not appear to be generally available.† It is probably identical with one introduced later and independently by M. S. Bartlett, and described in his North Carolina lectures (**2**). In this one considers the function

$$\varphi\begin{pmatrix} z, t \\ n, s \end{pmatrix} = \sum_{m=0}^{\infty} z^m P\begin{pmatrix} m, t \\ n, s \end{pmatrix}, \qquad (18)$$

which satisfies a partial differential equation corresponding to the differential-difference relation (17). For example, the equation for the (λ_0, μ_0) process is

$$\frac{\delta\varphi}{\delta t} = (z - 1)(\lambda_0 z - \mu_0)\frac{\delta\varphi}{\delta z}, \qquad (19)$$

with the initial condition

$$\varphi\begin{pmatrix} z, s \\ n, s \end{pmatrix} = z^n, \qquad (20)$$

and this can readily be solved to give Palm's formulae for the transition probabilities $P(m, t)$.

* See, for example, Professor Greenwood's paper, "The statistical study of infectious diseases," recently communicated to the Society.

† However, I understand from Professor Feller that there are some relevant papers by Palm in the Journal, *Ericson Technics*, of the L. M. Ericson Telephone Company.

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Recently (**10**) I have used the same method to find the complete solution to the equations for the generalized "birth-and-death" process in which the birth and death rates λ and μ can be any functions of the time t; as a particular case one can therefore write down the $P(m, t)$ for Arley's $(\lambda_0, \mu_1 t)$ process.

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An Experiment in Census Tabulation. Census of Cyprus, 1946

By D. A. Percival

When a census of population is taken it is usually not less than six months before the authorities, even when equipped with punch-card machinery, are able to issue classified results. For the Cyprus census of 1946 it was desirable that provisional results by the main classifications of age and community should be economically produced within a few weeks of the census date. The authorities, therefore, employed a procedure (which it is believed has not been previously employed in population census work) of compiling preliminary figures from punched cards pulled from prepared trays by unskilled operators on the strength of a partial scrutiny of the census forms. The procedure was suggested and devised by Mr. C. Shread, Middle East Representative of the Powers-Samas Accounting Machines Company. As will be seen, primary results in adequate detail were thereby made available after little more than one month—that is, some six months sooner than would have been possible with the same staff and equipment by the normal punch-card procedure.

Cyprus has a population divided into religious-racial communities, of which Greek Orthodox (80 per cent.) predominates greatly, the minorities comprising Moslem Turks (18 per cent.) and a number of Armenians, Maronites, British, etc., who were grouped together as "Other Religions" (2 per cent.). For the preliminary census tables each of these communities was divided by sexes into four "economic" age-groups (0–5, 6–13, 14–64 and 65-and-over), the total classifications thus numbering twenty-four. As will be obvious from the figures given, the twenty-four categories were extremely uneven in size.

The census forms, one for each individual, had been compiled by enumerators in blocks usually of 400 to 500 persons, the forms for each block being contained in a large canvas envelope. For each dwelling there was also a household schedule forming an attachment to the individual form of the head of household and giving a list of the persons enumerated in that dwelling, together with certain housing particulars. The sex, age and religion of each person were entered in the first three cages of the individual form. In case the system were to be used again, it would be arranged for all the particulars necessary for the primary count to be entered against the individual's name on his household schedule, so that the necessity of referring to the several individual forms would be avoided.

Three columns in a 65-column punch-card were devoted to the primary census work, one for each community in order of importance. As may be seen from the diagram (Appendix I), the eight sex-and-age classifications, which were considered to be adequate for the needs of the Cyprus census, did not fill the column, and for general use one would recommend breaking up the big 14 to 64 group. These three columns of the primary count were not designed to be put in use in the final census work. The first process was to punch cards on an automatic key punch into the twenty-four categories on the basis of figures previously estimated. Each card was punched with three holes, one to supply the total population, one to supply the total for the religious community, and the third to show the sex, religion and age-group of the individual. The diagram shows a card punched for a Moslem male of 65-or-over.

In the unavoidable absence of proper steel equipment the cards were arranged in hand-made cardboard boxes measuring 27 in. by 4½ in. by 4½ in. Each box was divided into compartments by movable cardboard slats inclined at a convenient angle, the category of card behind each slat being clearly indicated. The operator, who was in most cases a young girl straight from school, pulled her cards from five boxes, two each for Greek-Orthodox and Moslem (males and females) with four age-group compartments, and one for "Other Religions" (both sexes) with eight age-group compartments.

The operators were arranged in pairs, one girl turning up the forms and reading the three particulars, while the other pulled an appropriate card from the boxes. At intervals the two girls would exchange duties. In the first day's work of six hours each pair of operators pulled approximately 2,500 cards, and in the first full week the average per pair was over 20,000. As the work proceeded higher speeds were attained, and before the end of the work the pairs of operators were averaging 4,500 cards in a working day, the highest output reached by a pair

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being 6,100. The whole work of enumerating the 450,000 inhabitants was carried out by six pairs of operators in exactly one calendar month. The time required for coding, punching and verifying the same number of full census cards, with the same operators and the equivalent coding staff, proved to be approximately seven months.

As the cards for each block were pulled they were passed to the machine-room for analysis, together with the envelope containing the forms. It had been hoped to carry out the work on a three-bank counting-machine and a tabulator, which would have produced the results mechanically in type, but since these machines were not at hand use was made of the only available machine, an ordinary counting sorting machine, the figures being copied onto appropriate working sheets by hand, and the final additions made on an adding machine. Each batch of cards on reaching the sorter was first counted on the column for the Greek-Orthodox, which gave the results of that community and also the total persons in the whole block. This total would be compared with the total number of persons in the block as written on the outside of the envelope by the enumerator on the census date, and would be accepted unless it was more than 1 per cent. from that figure, in which case the number of forms in the envelope would be hand-counted. The sex and age-group figures for the Greek-Orthodox community would then be written by the sorting machine-operator in prepared spaces on the envelope, after which the process would be repeated on the remaining two columns (Moslem and Other Religions) in cases where the block included persons of those communities. After checking the cross-additions, the sorter-operator would set aside the cards of the block for future use and send the envelope to the officer responsible for compiling the statistics. The latter would scrutinize the figures to see if any item appeared to require investigation and, if the figures were in order, enter them on the appropriate working sheets. Two basic tabulations were produced (in the form of Tables "A" and "B" of Appendix II), the former by villages and the latter by districts only.

The method of operation described is obviously liable to some degree of inaccuracy. Inaccuracies were found to arise either from specific instances of carelessness, or from the general operating error inevitable in a fast unchecked work of this kind.

Protection against carelessness is afforded by comparison with the enumerator's count and also by the common sense of the statistical workers, comparisons with previous census results, etc., and it is believed that in the Cyprus census all significant errors were eliminated from the resultant figures. Such errors may arise—

(i) If a batch of pre-punched cards is misplaced in a box. This is relatively infrequent, but occurred more than once.

(ii) If some feature of the forms misleads the operators. In the Cyprus case the forms were printed in three languages, Greek, Turkish and English. The language of the form normally corresponds with the religion of the person enumerated, but in certain areas of mixed population there would be a minority of Greeks enumerated by a Turkish enumerator or *vice versa*, and this gave rise to mistakes on several occasions. Another source of error was the inclusion of certain cancelled forms, contained in the envelopes in accordance with the enumerators' instructions.

(iii) If an entry is made by the sorting machine-operator in the wrong cage or the wrong column. Errors from this cause were rare and usually soon detectable, but their possibility cannot be ignored, especially in cases where the categories are very unequal and where several cages emerge with a *nil* entry.

To ascertain the degree of general operating accuracy a considerable number of blocks were re-pulled, either for tracing suspected mistakes or simply for test purposes. The second pull was made at slower speed, and was presumed to be the more accurate of the two in cases where difference occurred. An analysis of the re-pull covering 8·8 per cent. of the population is set out (Appendix III). It shows variations ranging from 12·6 per thousand in small groups to about 1 per thousand in large ones. As was expected, the re-pull suggested that the figures contained some bias against small minority groups of "Other Religions" and "Aged 65 +". It suggested also a slight bias against females, no doubt explained by the fact that the first form in a household group is usually a man. The level of accuracy indicated was, however, satisfactory and fully adequate for administrative and general purposes. More recently an analysis has been made comparing the pulled-card results for some two-thirds of the island with the full results obtained

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from cards punched by operators in the normal way. Some figures from this analysis are set out (Appendix IV). The results confirm the previous assessment of accuracy with the one exception of the very small "Other Religion" group in rural areas, in which an undue proportion was missed. This result suggests that it is preferable to avoid including such very small minority classifications when the pulled-card method is to be used. Where figures for such persons are required a distinctive form should be completed for them.

Summarizing the experiment it is claimed that the results were satisfactory, particularly considering the rather special difficulties of working with forms in three languages, and with a staff totally new to punch-card work, and indeed to statistical work of any kind. On future occasions it would be possible to foresee and avoid most of the difficulties which occurred in this case. It is suggested that not more than fifty categories should be employed, and that the rate of work for newly trained operators should not be permitted to exceed 4,500 cards per pair in a working day of six hours. For census purposes (where plus and minus errors generally cancel each other), one may in such conditions reasonably hope for an accuracy of 1 per cent. in figures between 100 and 1,000, increasing to 1 per thousand in figures of 10,000 and over. With important censuses in contemplation in many countries, it is to be hoped that other census authorities working in more favourable conditions will develop this procedure for securing early census results, which appears to be capable of very considerable expansion.

Appendix I

Punch-Card Columns used for Compiling Preliminary Results

Position.	1st Column.	2nd Column.	3rd Column.	
12	*Greek Orthodox.*	*Moslem.*	*Other Religions.*	
11	*G.O.*	(*M.*)	*O.R.*	Hole for count of religions.
		Males.		
0	0	to	5	
1	6	to	13	
2	14	to	64	
3	65	(UP)	..	Hole for individual particulars. (Sex, age and religion.)
		Females.		
4	0	to	5	
5	6	to	13	
6	14	to	64	
7	65	UP	..	
8	—	—	—	
9	(TOT)	—	—	Hole for count of total.

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Appendix II

Specimen of Table "A"

Table showing the population by sexes, religions and age-groups, and the number of inhabited dwellings.

Famagusta District

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
		Age-groups.									*Sexes.*		*Religions.*			
Code No.	*Males.*				*Females.*				*Name of Village.*	*Total population.*	*Males.*	*Females.*	*Greek Orth.*	*Moslem.*	*Other religions.*	*Inhabited dwellings.*
	0–5.	6–13.	14–64.	65 *and over.*	0–5.	6–13.	14–64.	65 *and over.*								
6/200	132	128	532	85	90	140	601	83	Akanthou	1,791	877	914	1,783	8	—	518
6/1	77	113	259	20	82	106	265	20	Akhyritou	942	469	473	933	8	1	202
6/2	5	4	22	3	10	12	20	1	Aloa (Aloda)	77	34	43	4	73	—	19

Specimen of Table "B"

Table showing the Religious Communities distributed by Sex and by Economic Age-Groups (Military and Shipping included)

Famagusta

Area.	*Religious Community.*	*Total all ages.*	*Both Sexes.*				*Males.*				*Females.*			
			0–5.	6–13.	14–64.	65 *and over.*	0–5.	6–13.	14–64.	65 *and over.*	0–5.	6–13.	14–64.	65 *and over.*
Famagusta District, including towns	All Religions	94,154	14,009	17,182	57,013	5,950	7,199	8,738	27,409	2,936	6,810	8,444	29,604	3,014
	Greek-Orthodox.	78,105	11,486	14,039	47,573	5,007	5,926	7,111	22,774	2,499	5,560	6,928	24,799	2,508
	Moslem	15,735	2,506	3,112	9,197	920	1,263	1,610	1,512	425	1,243	1,502	4,685	495
	Other religions	314	17	31	243	23	10	17	123	12	7	14	120	11

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Appendix III

Results of original pulling compared with trial re-pulling

	Males.				Females.				Total population.	Sexes.		Religions.		
	0–5.	6–13.	14–64.	65 and over.	0–5.	6–13.	14–64.	65 and over.		Males.	Females.	Greek Orth.	Moslem.	Other religions.
Total, Five Tests (110 blocks)—														
1st pull	2,939	3,537	12,371	1,144	2,797	3,357	12,392	1,221	39,758	19,991	19,767	26,973	12,549	236
2nd ,,	2,935	3,540	12,344	1,157	2,811	3,337	12,379	1,239	39,742	19,976	19,766	26,972	12,531	239
No. 1. Famagusta Villages (30 blocks)—														
1st pull	1,033	1,269	3,548	389	998	1,238	4,071	440	12,986	6,239	6,747	7,392	5,586	8
2nd ,,	1,031	1,270	3,548	402	992	1,250	4,047	441	12,981	6,251	6,730	7,387	5,582	12
No. 2. Limassol Villages (39 blocks)—														
1st pull	772	934	3,168	348	709	838	3,035	324	10,128	5,222	4,906	8,454	1,646	28
2nd ,,	758	937	3,168	350	724	827	3,018	332	10,114	5,213	4,901	8,460	1,625	29
No. 3. Paphos Villages (29 blocks)—														
1st pull	748	788	2,673	252	674	779	2,797	247	8,958	4,461	4,497	4,391	4,543	24
2nd ,,	758	784	2,659	246	676	779	2,799	260	8,961	4,447	4,514	4,396	4,535	30
No. 4. Nicosia Town (7 blocks)—														
1st pull	173	283	1,706	87	208	262	1,363	133	4,215	2,249	1,966	3,851	276	88
2nd ,,	175	284	1,695	91	214	244	1,382	131	4,216	2,245	1,971	3,853	277	86
No. 5. Famagusta Town (5 blocks)—														
1st pull	213	263	1,276	68	208	240	1,126	77	3,471	1,820	1,651	2,885	498	88
2nd ,,	213	265	1,274	68	205	237	1,133	75	3,470	1,820	1,650	2,876	512	82
Difference actual between 1st and 2nd pull	+4	−3	+27	−13	−14	+20	+13	−18	+16	+15	+1	+1	+18	−3
Per 1,000	1·3	0·8	2·2	11·1	5·0	6·0	1·1	14·5	0·4	0·8	0·1	—	1·5	12·6

Appendix IV

1. The analysis of the figures for six district towns and for the villages of five districts, i.e. a total of approximately 340,000 persons out of 450,000, gives the results shown below:—

Comparison between Primary and Actual Results.

	Total	Sex.	Religion.	Age.

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Appendix IV

1. The analysis of the figures for six district towns and for the villages of five districts, i.e. a total of approximately 340,000 persons out of 450,000, gives the results shown below:—

Comparison between Primary and Actual Results.

Area.		*Total Population.*	*Sex.*		*Religion.*			*Age.*			
			Males.	*Females.*	*Greek Orthodox.*	*Moslem (Turkish).*	*Other Religions.*	*0–5.*	*6–13.*	*14–64.*	*65 and over.*
Six District Towns	Primary.	96,903	49,348	47,555	69,344	22,129	5,430	11,069	13,639	67,184	5,011
	Actual	96,975	49,378	47,597	69,100	22,121	5,754	11,079	13,588	67,244	5,064
	Difference	−72	−30	−42	+244	+8	−324	−10	+51	−60	−53
	Per 1,000	0·7	0·6	0·9	3·5	0·4	56·5	0·9	3·7	0·9	10·5
Kyrenia Villages	Primary.	25,272	12,066	13,206	20,548	3,212	1,512	3,742	4,495	15,179	1,856
	Actual	25,273	12,059	13,214	20,494	3,224	1,555	Not available.			
	Difference	−1	+7	−8	+54	−12	−43	..	..	..	..
	Per 1,000	—	0·6	0·6	2·6	3·7	27·6	..	..	..	..
Famagusta and Larnaca Villages	Primary.	115,632	56,407	59,225	94,364	21,210	58	18,185	21,726	67,971	7,750
	Actual	115,697	56,367	59,330	94,388	21,175	134	18,220	21,793	67,851	7,833
	Difference	−65	+40	−105	−24	+35	−76	−35	−67	+120	−83
	Per 1,000	0·6	0·7	1·7	0·3	1·7	559·0	1·9	3·0	1·8	10·6
Limassol and Paphos Villages	Primary.	100,646	49,984	50,662	83,905	16,652	89	15,839	17,999	60,297	6,511
	Actual	100,710	49,943	50,767	83,963	16,639	108	15,812	18,005	60,275	6,618
	Difference	−64	+41	−105	−58	+13	−19	+27	−6	+22	−107
	Per 1,000	0·6	0·8	2·1	0·7	0·1	17·4	1·7	0·3	0·3	16·0

Note.—The "actual figures" quoted are those taken from the first analysis of cards punched in the normal manner. The published Census figures will in some instances differ slightly from those quoted on account of later amendments.

2. To assess the accuracy of the results village by village the two sets of figures for sex and religion were set out in the following form for 131 villages and village-quarters out of the whole 645 in the Island. Actual figures of age-groups by villages are not available for comparison.

Specimen Analysis

Village Code No.	*Total.*			*Sex.*						*Religion.*								
				Males.			*Females.*			*Greek Orth.*			*Moslem.*			*Others.*		
	Pr.	*Act.*	*Dif.*	*Pr.*	*Act.*	*Dif.*	*Pr.*	*Act.*	*Dif.*	*Pr.*	*Act.*	*Dif.*	*Pr.*	*Act.*	*Dif.*	*Pr.*	*Act.*	*Dif.*
8/29	582	580	+2	300	301	−1	282	279	+3	41	38	+3	541	542	−1	..	..	..
8/30	576	576	..	270	271	−1	306	305	+1	434	434	..	142	142	..	..	..	..
8/31	706	707	−1	355	354	+1	351	353	−2	As for total			..	..	..	..	..	..
		etc.			etc.									etc.				

In these figures the largest individual difference was 21. The standard deviations from a difference of "*Nil*" calculated for each column omitting those entries for religion where one religious community made up the total population), resulted as follows:—

	Average per village.	*Standard deviations.*
All persons	477	2·61
Males	233	3·05
Females	244	3·35
Greek Orthodox	349	4·55
Moslem Turkish	150	4·40
Other religions	40	4·36

It thus appears that one must expect an error factor of from 2 to 4 in any individual entry, which is eliminated in the total figure and in the equal categories of the sexes, but is partially cumulative in the unequal categories of religious communities.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

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1.—*The Advanced Theory of Statistics*. By Maurice G. Kendall. Vol. II. London: Charles Griffin, 1946. 10″ × 8″. vii + 521 pp. 50*s*.

Those of us who are concerned with the application of the mathematical theory of statistics have awaited the publication of Mr. Kendall's second volume with a lively interest. The main emphasis in Vol. I was given to the discussion of the mathematical properties of distribution functions and to the development of techniques useful in their study. Numerous illustrative examples were provided, but inevitably there was at times some lack of forcefulness in their handling, because it came in advance of any discussion of the broad principles on which inferences are drawn from statistical data in terms of probability. What the author terms the logic of statistical inference has now been treated very fully in Vol. II, and the practical problems of regression and the analysis of variance, which are given in neighbouring chapters, provide ample material on which the reader may test this logic.

Clearly the order of presentation of the subject adopted by Mr. Kendall will not always be the most appropriate, but it is now possible for the mathematical statistician who knows the elements of the subject to go through the two volumes in any order he likes, and so the completed work takes its place as a quite invaluable reference book. The assistance which it will provide in teaching an advanced class is, as I see it, very considerable. It will be possible in future to leave a good deal of mathematical treatment to the students' reading and to concentrate on the essentials of method, the guiding ideas and the training in what Mr. Kendall aptly terms "self discipline in the use of advanced theoretical techniques."

The contents of Vol. II may be divided into three parts: (i) chapters dealing with the logic of statistical inference (17, 18, 19, 20, 26 and 27); (ii) those dealing with the methods of analysis largely built on the properties of sums of squares and products of normal variables (21, 22, 23, 24, 25 and 28); (iii) those concerned with the analysis of time series (29 and 30).

The problem of how to fit the discussion of the theories of estimation and testing of statistical hypotheses into the book was obviously a difficult one. Mr. Kendall decided to keep his treatment objective, which means, for example, that he presents parallel chapters on Neyman's theory of confidence intervals and Fisher's theory of fiducial inference. But the fact that he is being "fair all round" means that when, in describing the reasoning process by which conclusions are drawn from practical examples, he has need of a consistent logical approach, he sometimes cannot drive his argument home. This handicap is perhaps particularly noticeable in Chapter 21 on "Some common tests of significance." Throughout the two volumes the reader may often have found himself wishing that he knew "what Kendall really thinks." In this chapter (§ 21.1–21.8) we are given some insight into his views on the justification for the common procedure used in carrying out tests of significance, which he relates back to the theory of interval estimation. But he does not write as if he were quite confident that this approach is altogether satisfactory and, at the end of the chapter, he has accumulated such a number of different alternative methods of dealing with the main significance problems that the reader, anxious for guidance in tackling new situations, may be left in a little confusion.

Now the approach to the testing of statistical hypotheses which Neyman and I developed and which is fully and fairly presented later in Chapter 25 and 26 has as its purpose a synthesis of the solutions of these different problems. It may or may not be generally acceptable, but presumably because it is regarded by Kendall as controversial, it is kept within its allotted chapters and its application to the problems of Chapter 21 is not discussed. For example, from lack of guidance the reader might suppose that the illustration of weighing bags of sugar introduced in Ex. 21.1 (p. 99) is being dealt with on the lines later discussed in Chapter 25. But this is not the case, and a useful opportunity has been missed of discussing alternative ways in which the risks

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that the manufacturer has to face can be related to probability measures associated with a statistical test.

The view that either the theory of estimation or that of testing hypotheses are abtruse and must be left for late consideration is, I am convinced, mistaken. They are concerned with the shaping of an analytical technique based on the theory of probability in such a form as to satisfy intuitive requirements of a calculus that is to aid us in reaching decisions from numerical data. The idea of comparing the power functions of two tests is no more difficult to grasp than that of comparing the sampling variances of two alternative estimators of a parameter. Experience shows that basic ideas of this kind can be introduced usefully at an early stage in teaching, and long before it is necessary to deal rigorously with the admittedly elaborate mathematical analysis required to establish existence theorems or maximum properties.

As we all know only too well as practising statisticians, the distributions of experience do not always conform to those mathematical laws which lend themselves to the determination of optimum techniques based, say, on sufficient statistics. But the broad requirement of a good technique, since it aims at satisfying the scientific mode of reasoning, is something which must be independent of the functional form of the probability distributions which we happen to meet.

As was to be expected from the standard he has set himself, Mr. Kendall's chapters on the analysis of variance contain the clear statement of the mathematical set-up and assumptions that is so often missing in current books on Statistics. He has spared no effort to make clear in algebraic form and by discussion of numerical examples, points which the beginner has frequent need to turn over in his mind—the interpretation of sums of squares when the hypothesis tested does not hold, the meaning of interactions, the difference between "normal" and randomization theory, etc.

The fascination which the mathematical mind finds in the development of more and more complex experimental designs has its obvious dangers. Mr. Kendall's handling of his illustrative material aims at encouraging the student in the critical appreciation of his primary material. It is indeed instructive to go even further into this process and to go through the numerical examples given in Chapters 23 and 24, using diagrammatic representation to the limit imposed by two dimensions. One sees then how a number of the conclusions reached by arithmetical analysis are at once obvious to visual inspection and how, in other cases, the conditions assumed by theory are hardly borne out. For instance, a simple spot diagram of Bartlett's germination example (p. 208) and a little elementary calculation shows that the transformation of variable carried out at some length is in this instance scarcely justifiable, since there is no suggestion whatever that the variance within groups increases with the mean.

One of the greatest contributions of the advanced theory of statistics lies in the way in which it trains the mind to think when faced with the planning and interpretation of scientific inquiries. Because this training gives a great impetus to clear thinking, it is not wasted even if, perhaps, more problems than are commonly admitted submit to simple handling, graphical inspection and the application of common sense. Mr. Kendall's book provides a wealth of material to illustrate the various aspects of this text.

Chapter 25 on "The design of sampling inquiries" does not attempt to be exhaustive, but is a really useful statement of principles and ways and means.

The last two chapters of the volume on Time Series, as the final chapter of Vol. I on Rank Correlation, deal with a field in which Mr. Kendall has himself made notable contributions. The subject is one in which exploration has far to go, and where the advancement of mathematical theory must proceed in very close touch with an understanding of the physical and economic phenomena which it aims at representing and analyzing. The author is aware of this, and the chapters provide an admirable example of the Statistician at work on a difficult problem.

As in Vol. I, each chapter concludes with some useful notes and grouped references; there are also, again, a number of appropriate exercises. An extremely valuable Bibliography is included as an Appendix; it covers the subjects dealt with in both volumes. Presumably, in later editions there will be a common subject index to the two volumes. E. S. P.

2.—*Introduction to Mathematical Statistics.* By Paul G. Hoel, Associate Professor of Mathematics, University of California at Los Angeles. New York: John Wiley, 1947. (London: Chapman & Hall.) x + 258 pp. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. $3.50.

This is an excellent introduction to the subject intended for a first "two-semester" course for American students. It will, however, be very useful to English students who know some calculus but not a great deal. In the author's own words: "The topics in the first seven chapters of this book are largely concerned with the theory of certain large sample methods in statistical theory. They have been arranged according to the number of variables being studied. First problems

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dealing with one variable are considered, then problems dealing with the relationship between two variables, and finally problems dealing with more than two variables. In each problem the descriptive methods of treating the data are considered first, after which the theoretical counterpart or mathematical model is considered. With more than two variables, the theoretical model becomes somewhat complicated and therefore will not be treated here. The topics in the last five chapters are largely concerned with the theory of certain modern methods in statistics, including in particular some of the important small-sample methods."

After an introduction, Chapter II deals with actual, Chapter III with theoretical frequency distributions in one variable. In Chapter III the moment-generating function is introduced early and used in the treatment of the normal, binomial and Poisson distributions. The normal approximation to the binomial then follows easily from the limit of the moment-generating function. It is assumed but clearly stated that a distribution function is determined uniquely by its moment-generating function, and that if one distribution function has a moment-generating function which approaches the moment-generating function of a second distribution function, then the first distribution function approaches the second distribution function. This is an example of the author's decision to prove only such theorems as require a background of at most elementary calculus, and to state those which need advanced calculus. References to the proofs of the latter class of theorems are always given at the ends of chapters.

The fourth chapter deals with the large-sample theory of one variable, the fifth and sixth with actual and theoretical distribution in two variables, and the seventh with distributions in more than two variables including, of course, correlation and regression. In the seventh there is a useful section on linear discriminant functions.

The eighth chapter deals with the χ^2, t and variance ratio distributions as well as the distribution of the range; the ninth with certain non-parametric methods, Tchebycheff's inequality, a special case of tolerance limits, the use of runs to test randomness of sequences, concluding with a very short section on serial correlation.

Then follows the tenth chapter on testing goodness of fit, and the eleventh on testing statistical hypotheses, simple and composite, with an account of errors of the first and second kind. The Neyman-Pearson test for homogeneity of variances is given as an illustration and the result of Bartlett's test is quoted. The twelfth chapter is on statistical design in experiments. There is a very short section on analysis of variance, and a short account of some methods in stratified sampling, sampling inspection and sequential analysis. This part of the book is stimulating rather than sufficient.

There are very useful references and examples at the end of each chapter, and the author can be congratulated on producing a very useful, readable and concise text-book. J. O. I.

3.—*Statistical Quality Control.* By Eugene L. Grant. McGraw-Hill Publishing Co., Inc. London and New York. 1946. 9″ × 6″. xii + 563 pp. $5.00.

This book gives us at last a comprehensive survey of industrial Quality Control, excluding only most recent developments, such as sequential analysis, which is merely mentioned in a footnote. Of the "four levels" of understanding the mathematics, the general principles, the broad objectives and, lastly, the use of the technique (p. 17), the author, who is Professor of Economics of Engineering at Stanford University, aims at the second level. The reader is invited to take part in an adventure of learning from examples, from mistakes and from accidental discoveries. This is surely a stimulating way of studying a new subject. A few of the characteristic headings of paragraphs may be quoted: "165. Probability has a mathematical meaning." "230. Specification limits are not always enforced." "326. Who should get credit for savings from quality improvement?" Extensive use is made of examples. No. 10, for instance, is headed, "An unsound proposal for sorting product into classes." The first paragraph then deals with the "facts of the case," the next with "errors in reasoning involved."

The list of contents suggests a more methodological approach than is in fact intended. Control charts of variables, for fraction defective and for defects per unit, are dealt with, in this order, but the theoretical background is not entirely satisfactory. A Chapter on Probability introduces the binomial and the Poisson distribution (the reviewer finds the frequent reference to "the Poisson" irritating). Much earlier in the book the normal distribution is dealt with, but its connection with the other two types is ignored. The Dodge-Romig sampling schemes and the Standard Sampling Tables of the U.S. Army Service Forces receive the space which they deserve and the explanation of such notions as characteristics and AOQL, etc., is clear and competent. The last part, "Making statistical quality control work," makes good reading.

At the end of chapters we find "Problems," most of them well chosen, as for instance, "Why is

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it that an increase in universe dispersion with no change in universe average throws the $\bar{X}$-chart out of control as well as the R-chart?" Problem 69 (p. 219), on the other hand, is less happy, as it suggests that a certain approximation holds for n larger than (precisely) 25, leaving the reader guessing where this exact number comes from. The reviewer found two minor misprints (p. 96, line 18, should have $\bar{\bar{X}}$ in place of the second $\bar{X}$ and the fraction for P_c on p. 229 should have 170 in lieu of 240 in its denominator), and he makes an emphatic plea for references to be made to pages or articles, but not to tables and figures, which one cannot find without some hunting.

The book is excellently produced, and it will soon be acknowledged as one of the standard treatises on its subject.

S. V.

4.—*A Chapter in Population Sampling.* By the Sampling Staff of the Bureau of the Census. Washington: United States Government Printing Office, 1947. $9\frac{1}{4}'' + 6''$. vi × 141 pp. $1.00.

This monograph deals with a particular approach to stratified areal sampling with sub-sampling. It gives the principles of optimum allocation by which the smallest sampling error is obtained for a specified expenditure.

The particular problem discussed is that of population "census" by sampling methods, although the writers' belief is that "similar applications can be made in other fields." It is not, however, likely that the average Market Research or similar organization in this country will find much of direct application in this publication, at least, not until such time as the Government statistical organizations have first broken the back of the task, set up "block cities" and made the information available. Those responsible for the planning of official statistics generally, and in particular those who are interested in the next census of this country, should find the book stimulating. It reveals considerable differences between the American and British approach to the problem of population census.

The methods used for the example and described in the book were mainly possible because since the 1940 census America has had information about "block cities," all cities which in 1930 had a population of more than 50,000 being already divided into blocks or definable geographic areas.

Briefly the method is, first to sample the "blocks," listing all dwelling places within the blocks so selected; from these lists further samples are drawn, and investigators visit this final sample to determine the population within the dwelling places. All dwelling places outside any block are also completely listed and sampled separately. The basic principle was thus, by sampling, to ascertain the average number of persons per dwelling place, and the average number of dwelling places per block. From this the population could be estimated. An accuracy of ±1 per cent. was desired and apparently achieved.

As will be known, the cost per head of sampling is greater than the cost per head of a complete count. The point at which it becomes economical to sample is determined partly by the relative cost per head and partly by the degree of accuracy desired. The American experiment described in this monograph showed the line (for this particular case) to fall at about 13,500 dwelling places or 54,000 inhabitants per city. Other supplementary considerations led to complete counts being taken where the population of the area was 100,000 or less and to sample only in cities larger than this.

Some interesting and useful techniques for measuring and correcting for human errors in listing and sampling are given. In general, however, it is difficult to see how similar methods may be used in this country except for Government statistics, where, the reviewer believes, a lead should be given in the study and application of areal and other sampling techniques.

L. W.

5.—*A History of Banking Theory in Great Britain and the United States.* By Lloyd W. Mints. Chicago: University of Chicago Press (London: Cambridge University Press). 1945. 9″ × 6″. 319 pp. $3.50

This is a favourable specimen of those books which explore the origins of various branches of economic doctrine. To anyone who needs to find out how and when some piece of economic theory in the sphere of banking has grown up, it will be an invaluable work of reference. Of its 925 footnotes, many contain several separate items, and the exposition of what any writer had to say is nearly always concise and clear.

The author, however, would have been well advised to avoid some of his incursions on his own account into the realms of theory. In his preface he refers to the "real bills" doctrine, that "a restriction of the banks to the making of loans for *bona fide* commercial purposes will automatically

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provide for all needed variations in the means of payment." "If there is a central theme in what I have written," he observes, "it is that this doctrine is unsound in all its aspects."

That he is right in regarding it as unsound there would be very general agreement. But his theoretical argument (pp. 30–35), starting from the assumption that the supply of money is equated to loans *exactly* covering the entire stock of an "eligible" commodity, is so remote from facts that it contributes nothing to the controversy.

When Bagehot described the arguments based on the real bills doctrine by the Bank of England in 1810 as having become "almost classical by their nonsense" (p..183) he was voicing the general view. But that did not mean that there was no virtue at all in the doctrine. When bills were the predominant instrument of bank credit, the customer for whom a bank discounted a bill was the creditor, not the debtor. There was a presumption that a trader would only get bills discounted when he actually needed cash, and would hold the rest till maturity. If the banks confined their creation of credit to the purchase of genuine trade bills, the holders of the bills had to participate in the process, and they were a cautious and prudent class. The mistake the Bank of England Directors made in 1810 was in failing to see that a rise in the price level, once it did occur, would be automatically reflected in the bills drawn.

There is a difference between American and British practice. Whereas the bill of exchange of the London money market originates with the seller of goods, who is a creditor, the commercial paper of the American banking system consists of promissory notes originating with the buyer, who is a debtor. In the days when bills were the predominant form of credit in England it was easy for a banker to refuse to take bills even from his regular customers; it is more difficult to refuse to lend to a customer whether on a promissory note or on a simple overdraft. These practices are the essential background of the theorizing about real bills.

Mr. Mints, not content with condemning the real bills doctrine, goes so far as to advocate a complete elimination of short-term lending. His argument (pp. 218–222) is well enunciated, but can only be sustained on the tacit assumption that effective credit regulation by a central bank is impossible. And surely any such proposal is out of place in a history of banking theory, where it cannot be more than a brief digression. That is not to say that all theoretical comment should be eschewed in a history of theory. Mr. Mints's comments are often such as will help the reader to see the bearing of the doctrines he summarizes, for example, when he points out (p. 244) that a tax on reserve deficiencies, to be effective, would have to be "varied with circumstances in precisely the same manner as the rediscount rate of a central bank." R. G. H.

6.—*John Hilton: The Story of His Life*. By Edna Nixon. London: George Allen & Unwin, 1946. $8\frac{1}{4}'' \times 5\frac{1}{4}''$. 8 + 344 pp. 15*s*.

In our *Journal* (vol. cvi, 1943, pp. 293–4), over the well-known initials E.C.R., there is an excellent appreciation of John Hilton's contributions to the practice of statistics; to our knowledge of this side of Hilton's life Mrs. Nixon contributes little. The remark quoted by her, "I have never read a book on Statistics in my life and know nothing about the text-book side of it except what I've picked up" was no doubt true, and might have been inferred from Hilton's papers; but that weakness does not affect the value of what he succeeded in doing; it is owing to his energy and enthusiasm that statisticians with less drive but more scientific knowledge have obtained valuable data. Most readers, however, of E.C.R.'s appreciation, especially the quite large number of Fellows who knew Hilton personally, will find this biography interesting.

Hilton was not born with a silver spoon in his mouth and had to struggle against poverty, physical ill-health and—perhaps a Victorian might be permitted to say—fits of bad temper for many years. He often gave offence to individuals, and sometimes spoke contemptuously of subjects of which he knew little. But he won the affection of hundreds and the admiration of, literally, thousands. There cannot have been many men of his generation who did more to right petty injustices, to pillory shams and scandals, and to chastise the insolence of office. Yet he did this without assuming that, as a matter of course, officials were always insolent and incompetent, and the regulations of public departments oppressive. He became a master of the art of broadcasting; Mrs. Nixon's account of the immense pains he took to improve by patient study his natural advantages of voice, is the most interesting part of her book. Hilton was a very busy man; if he had had more leisure, some of the social weaknesses which Mrs. Nixon does not conceal, indeed—but this again is a Victorian prejudice—parades in a rather irritating way, would have been conquered, Queen Victoria, according to the anecdote, disliked Mr. Gladstone's habit of treating her like a public meeting. If we may be permitted to add one more guess to those of Mrs. Nixon as to why Hilton was not elected a Fellow of a College, it is that the electors, perhaps erroneously, had a fear they might be treated as Queen Victoria was. Probably, with leisure, Hilton would have become as welcome at a high table as he was in the Statistical Dining Club.

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The charm of the old-fashioned leisurely biography was often the wealth of personal letters. Mrs. Nixon quotes some—the delightful letter on pp. 154–5 in which Hilton describes the effect on a Berlin audience (in 1936) of quoting Heine, but attributing the lines to Goethe is a capital instance of the humour, and magnanimity, with which he could tell a funny story at his own expense—which whet the appetite for more.

We are all psychologists nowadays; Hilton's analyses of mass psychology were penetrating, and pp. 252–57, on Pool Betting, deserve careful study. The Chancellor of the Exchequer has set about the curtailment of one mass pleasure (or vice), but left another unpenalised. There is one obvious and compelling reason for the choice, but Hilton's opinion that Pool Betting was a serious psychological evil may still find adherents. The adjective "great" is overworked; it has been applied to many with less justification than Hilton's life story affords. M. G.

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STATISTICAL NOTES.

(1) British Official Statistics

The table below shows, in summary form, movements in the oversea trade of the United Kingdom in the third quarter of 1947, with comparable figures for the first two quarters of the year and for the years 1938 and 1946.

£ million

	1938	1946	1947		
	Quarterly average		First Quarter	Second Quarter	Third Quarter
Retained Imports, c.i.f.					
Food, drink and tobacco	104·5	156·1	182·4	211·8	227·3
Raw materials and articles mainly unmanufactured	54·5	90·4	89·8	128·3	158·6
Articles wholly or mainly manufactured	53·8	59·3	67·1	92·5	114·8
Other articles	1·7	6·9	6·2	5·1	5·6
Total	214·5	312·7	345·5	437·7	506·3
United Kingdom Exports, f.o.b.					
Food, drink and tobacco	9·0	15·9	12·9	14·9	17·7
Raw materials and articles mainly unmanufactured	14·2	8·3	10·0	9·1	7·8
Articles wholly or mainly manufactured—					
Metal goods	43·9	101·1	115·0	126·9	149·5
Textiles	25·3	46·6	52·7	52·8	57·2
Other manufactures	22·1	49·6	50·5	52·3	61·1
Other articles	3·2	7·2	8·6	8·9	9·1
Total	117·7	228·7	249·7	264·9	302·4
Exports of Imported Merchandise, f.o.b.	15·4	12·6	18·2	17·8	11·1

The total value of United Kingdom exports was £302·4 million, compared with £264·9 million in the preceding three months and £266·2 million in the fourth quarter of 1946—previously the peak post-war figure. Retained imports increased by £68·6 million and totalled £506·3 million, so that the adverse balance shown by the official statistics increased from £172·8 million to £203·9 million between the second and third quarters.

Total imports in the period under review were valued at £517·4 million, the corresponding figures for the first two quarters being £363·7 million and £455·5 million. Average values of imports are now 166 per cent. higher than in 1938 and, after allowing for this increase, imports in the quarter are estimated at 85 per cent. of the 1938 volume, compared with 66 per cent. and 76 per cent. in the first two quarters of the year. Re-exports fell from £17·8 million to £11·1 million and, in terms of volume, were less than one third of those in 1938.

Retained imports of raw materials (£158·6 million) and of manufactured articles (£114·8 million) each showed an expansion of nearly a quarter compared with the preceding three months; for food, drink and tobacco (£227·3 million) the increase was about 7 per cent. Among foodstuffs the most important increases were for dairy produce (86 per cent. of the pre-war volume) and for meat, fresh fruit and vegetables, and beverages (each only slightly below the 1938 volume); grain and flour imports fell to 71 per cent. of the pre-war volume and there were partly seasonal reductions for both miscellaneous foodstuffs and tobacco (only 50 per cent. of 1938). The volume of retained imports of raw materials was only 1 per cent, lower than in 1938. Most of the increase compared with the preceding quarter was due to the high level of supplies of wood and timber, which were valued at £41·8 million (125 per cent. of the 1938 volume—more than double those in the preceding quarter). Apart from oils, oilseeds, etc., which remained substantially unchanged, and cotton, retained imports of which fell to 46 per cent. of the pre-war volume, increases were also recorded for all the other principal groups. Retained imports of manufactured goods (£114·8 million) were one sixth below the 1938 volume, but the two largest groups—manufactured oils, fats and resins (essentially petroleum) and non-ferrous

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metals and manufactures—increased to 15 per cent. and 37 per cent. respectively above the average for the pre-war year.

Average values of United Kingdom exports in the third quarter were 126 per cent. higher than in 1938 and, after allowing for this increase, the volume of exports (of which N.A.A.F.I. and U.N.R.R.A. shipments formed only 2½ per cent.) was 114 per cent. of that in 1938. This compares with 102 per cent. in the preceding quarter and 111 per cent. in the fourth quarter of 1946, but is still one fifth below the overall target of 143 per cent. which has been announced for the middle of 1948. The July volume (126) was the highest so far recorded, but for the two holiday months, August and September, the figures were 105 and 111.

Exports of food, drink and tobacco (£17·7 million—86 per cent. of the 1938 volume) increased by one fifth, but those of raw materials, with negligible coal shipments and reduced exports of wool, fell to only 21 per cent. of the pre-war volume.

Exports of manufactured articles exceeded the pre-war volume by 31 per cent., being slightly above the peak figure for the fourth quarter of last year. The metals groups taken together, which account for 56 per cent. of total exports of manufactures, were 69 per cent. above the 1938 volume (compared with the fourth quarter figure of 54). Iron and steel exports (£22·6 million) were, in terms of volume, only 14 per cent. higher than in 1938, but for the other groups increases ranged from 68 per cent. for machinery (valued at £48·1 million) to more than double for vehicles (£45·8 million).

For textiles as a whole exports recovered to 72 per cent. of the 1938 volume, though they were still 7 per cent. below the end-1946 level, the heaviest reduction compared with the fourth quarter being in exports of apparel. Silk and rayon exports were substantially the same as in the preceding three months (two-fifths above 1938), but cotton goods (45 per cent. of 1938) and woollen and worsted manufactures (91 per cent. of 1938) increased by one tenth and one fifth respectively.

For all other manufactures exports (£61·1 million) showed a marked recovery compared with the first two quarters of the year and the value was higher than in any previous quarter ; in terms of volume, however, they still failed to reach the peak fourth quarter figure, the volume being 122 per cent. of 1938 compared with 128 per cent. at the end of 1946. Exports of chemicals, drugs, etc. (£18·9 million) exceeded the pre-war volume by over a half, and those of miscellaneous manufactures (£19·4 million) were nearly one quarter higher than in 1938.

Changes in the *collection of agricultural statistics* in Great Britain seem to be foreshadowed in the Agricultural Act, 1947, in which extensive powers are given to the Ministry of Agriculture and the Secretary of State for Scotland to issue compulsory regulations "for the purpose of obtaining statistical information relating to agriculture." Agricultural Statistics Advisory Committees are to be established (one for England and Wales and one for Scotland) to advise the Ministers in the making of these regulations, and these Committees are to include representatives of owners and farmers and of persons employed in agriculture.

The information which the regulations may require owners and occupiers of land to furnish is defined in very broad terms and may be of an extremely comprehensive character. It includes a number of items which have not previously been required, such as information as to rates payable, assessment under Schedule A, production, fixed and other equipment, stocks of produce and requisites, methods of marketing, wages paid and hours worked. There is also provision for obtaining information through a personal representative, either orally or in writing. The production of a balance sheet or profit and loss account is excluded.

The confidential character of the information to be supplied is preserved, subject to its disclosure in officially authorized cases, and "the use of the information in any manner the Minister thinks necessary or expedient in connection with the maintenance of the supply of food in the United Kingdom." The Agricultural Returns Act, 1925, under which the annual statistics have hitherto been collected, is repealed.

The publication of the *Annual Agricultural Statistics*, which was suspended during the war, is now being resumed, and as a first instalment the statistics for England and Wales, Scotland and Northern Ireland with totals for the United Kingdom for the years 1939–44 have now been issued in one volume (*Agricultural Statistics*, 1939–44, *United Kingdom*, Part I. Stationery Office. Price 1s. net). This meets the obvious need for a publication bringing together all the available statistics of the United Kingdom, and shows how the figures are built up from the statistics collected separately for each country.

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The present volume gives figures of the acreage and production of crops, and numbers of livestock, agricultural workers, agricultural holdings, and certain descriptions of agricultural machinery. The totals and most of the conclusions to be drawn as to the great changes in the agricultural industry consequent on the war have already been published in the *Statistics Relating to the War Effort of the United Kingdom* (Cmd. 6564), but the present volume is welcome as giving more detailed information both for each year separately and for the three parts of the Kingdom.

In Part II, to be issued later, it is proposed to give statistics of the agricultural output of the United Kingdom, with a general commentary on the statistical material available concerning the home agricultural industry. In this connection, it is remarked in an introductory note that present estimates of output and their derived statistics incorporate much detailed information now available for the first time through the operation of control measures, particularly those administered by the Ministry of Food. It is also noted that in order to avoid unnecessary demands on farmers for information, the question whether some of the enquiries could be made on a sample basis without undue sacrifice of accuracy is being considered. Broadly speaking, however, the needs of agricultural policy and administration, and of employment policy, seem likely to preclude any appreciable reduction in the scale of the information collected at the present time.

At mid-June, 1947, the *cost of living index* prepared by the Ministry of Labour and National Service was the same as at November 1, 1946. Up to April, 1947, the indices for the different groups of items showed little change compared with November, 1946, apart from slight increases in the prices of fuel and light and miscellaneous items, which were offset by a slight reduction in clothing prices. At May 1, however, there was a substantial rise in the index for miscellaneous items resulting from the increase in the tobacco duty, but this was counterbalanced by a reduction in the food index resulting from decreases in the price of butter, sugar and eggs. Other changes which affected the indices between November, 1946, and June, 1947, were increases in local rates in May, reductions in the maximum prices of some kinds of clothing in February and March, followed in May and June by some increases, a rise in coal prices in March, and increases in London road and rail fares in February.

The index numbers for the various groups of commodities are given below:

(Prices at July, 1914 = 100)

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Other Items*	*Total*
November 1, 1946	168	168	345–350	278	297	203
December ,,	168	168	345–350	279	297	204
January 1947	168	168	345–350	279	297	204
February ,,	168	168	340–345	279	297	203
March ,,	169	168	340	280	299	204
April ,,	168	168	340–345	283	302	203
May ,,	162	174	340–345	282	356	203
June ,,	161	175	345	283	356	203
Mid-June ,,	161	175	345	283	356	203
June 1, 1946	169	168	345	276	290	203
September 1, 1939	138	162	205–210	180–185	180	155
Percentage increase at June, 1947, over June, 1946.	4·7*	4·2	—	2·5	22·8	—
September, 1939	17	8	66	55	99	31

* Decrease.

The cost of living index on the 1914 base was calculated for the last time in respect of June 17, 1947. As from that date a new index of retail prices has been calculated with prices at June 17 taken as = 100. The new index is on a much wider basis, and the weighting system is based on the pattern of consumption revealed by the Ministry of Labour Budget Inquiry into working-class expenditure in 1937–38. The index is described as an interim measure pending further study and examination, which will be necessary before a new index based on a more

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up-to-date pattern of consumption can be adopted. The index numbers in the new series for July, August and September are given in the following table:

(Prices at June 17, 1947 = 100)

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Drink and Tobacco*	*Total*
Weights	348	88	97	65	71	35	79	217	1,000
July 15, 1947	101·2	100·0	101·5	100·1	101·7	100·6	100·1	100·0	101
Aug. 12, ,,	99·4	100·0	101·6	100·0	102·6	100·7	100·2	100·0	100
Sept. 16, ,,	99·6	100·0	101·3	103·6	102·4	105·0	100·5	100·0	101

In publishing the figures the Ministry of Labour states that they are in the form in which they are used in the procedure adopted for calculating the index for all the groups combined, i.e. to the nearest first place of decimals. The decimals are shown only in order that, if desired, calculations can be made of the effect of combining particular groups and excluding others. The information available as to price changes, however, is such that no precise significance can be attributed to the decimals, and for any other purposes, therefore, the figures should be used to the nearest whole number.

The level of unemployment continued fairly steady till the end of 1946. The exceptionally severe weather and the fuel and power restrictions, however, resulted in a very large temporary increase in the numbers unemployed in February, when the figure reached 1,874,000. In addition considerable numbers were stood-off from employment but continued to receive wages under guaranteed week and other arrangements and did not, therefore, register as unemployed. The number in this category at February 22 is estimated to have been about 503,000. The figures for March and April showed a considerable decline, and by May the total was below that reached for the end of 1946. The decline continued, and by September the figure was the lowest since October, 1945.

Number of Unemployed Persons on the Registers of the Employment Exchanges of the Ministry of Labour and National Service at the Undermentioned Dates

Date	*Insured Unemployed*			*Total (Insured and Uninsured)*
	Men and Boys	*Women and Girls*	*Total*	
October 14, 1946	268,924	96,734	365,658	377,576
November 11, ,,	269,274	97,257	366,531	376,214
December 9, ,,	269,660	93,316	362,976	370,108
January 13, 1947	301,928	99,321	401,249	415,770
February 22, ,,	1,251,338	622,723	1,874,061	Not available
March 10, ,,	589,642	175,206	764,848	773,183
April 14, ,,	318,343	108,646	426,989	442,741
May 12, ,,	246,424	85,119	331,543	343,729
June 16, ,,	202,220	70,116	272,336	284,040
July 14, ,,	190,325	65,221	255,546	266,870
August 11, ,,	186,204	63,487	249,691	262,787
September 15, ,,	176,811	63,101	239,912	254,009
September 16, 1946	267,895	91,311	359,206	373,603

The total for September, 1947, includes 30,823 married women and 8,684 ex-Service personnel who had had no employment since leaving the Forces. The 14,097 uninsured persons on the register at August 11 included 4,370 boys and girls under 18 who had not yet entered industry. The totals do not include men and women on the register who are classified as unsuitable for ordinary employment. These included at September 15, 17,333 insured men, 626 insured women and 1,081 uninsured persons.

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CURRENT NOTES

The National Institute of Social and Economic Research has issued an interesting Report for private circulation on some problems of social and economic research that arise from the relations between Government departments and academic bodies. The Report was the outcome of a private conference held under the Institute's auspices in March, 1947, and is signed by a large number of economists, statisticians and others in their personal capacities.

The starting-point of the Report is a recommendation of the Report of the Committee on the Provision for Social and Economic Research (known as the Clapham Committee Report) that a standing interdepartmental economic and social research committee be set up to survey and advise upon research work in Government departments. This Standing Committee was accordingly set up, and the present Report is offered as a contribution towards helping it in its work.

The recommendations of the Report include the following:

(*a*) that direct contact between individual research workers and responsible departmental officials are of primary importance and should be encouraged in every way;

(*b*) that there should be produced an inventory of the major collections of statistical and other material available in Government departments;

(*c*) that the general principles governing the confidential character of official material should be formulated;

(*d*) that outside statistical research workers needing help in making official contacts might receive it through the medium of a liaison officer in the Central Statistical Office;

(*e*) that responsible research workers should be permitted to work inside departments;

(*f*) that the practice of permitting officials to sign articles which are published in learned and official journals should be extended.

These and other recommendations, if adopted, would have a profound effect on encouraging research into the mass of statistical material which is at present lying dormant in the archives of Government departments, and it is to be hoped that they will be acted upon. The Report concludes with an interesting appendix giving an illustrative list of some major collections of material which are known to exist in Government departments or should be readily compiled from existing or future collections.

The Trustees of the Houblon-Norman Fund, on the recommendation of the Advisory Committee, have made the following awards for 1947–48:—

Fellowship (renewed for a second year): P. J. Watkin, B.A., University College, Swansea, "Financial Facilities for Industry in South Wales."

Research Grants: D. R. Marsh, B.A., Bank Official, "Rise and Growth of Corporate Executors and Trustees"; renewed for a second year, P. S. Sumner, M.Sc., B.A., Assistant Master, Worcester College for the Blind, "The Economics of Investment Trusts."

An offer of awards for 1948–49 will be made early in 1948. Further information may be obtained from the Secretary, Houblon-Norman Fund, c/o Bank of England, E.C. 2.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

The Advancement of Science—

June 1947—London traffic and the London plan: report of a conference. The numbers and distribution of mankind: *C. B. Fawcett.*

Annals of Eugenics—

June 1947—Sensory thresholds for solutions of phenyl-thio-carbamide. Results of tests on a large sample, made by R. A. Fisher: *D. S. Falconer.* Note on the calculation of the frequencies of *Rhesus* allelomorphs: *R. A. Fisher.* Some notes on discrimination: *L. S. Penrose.* A factor analysis of body measurements for British adult males: *Cyril Burt* and *Charlotte Banks.* An extension of the least-squares method for statistical estimation: *D. D. Kosambi.* Some examples of discrimination: *Cedric A. B. Smith.*

The Banker—

March 1947—Future of cost-of-living subsidies: *Edward Charles.* The changing discount market: I—Landmarks in Lombard Street. II—Financing the bond-dealers: *W. T. C. King.* Life assurance and the value of money: *Leo T. Little.*

May 1947—Industrial Wales: reconversion—and beyond: *E. Victor Morgan.* Industrial Wales: developing new industries: *John Pares.* Industrial Wales: plans for tinplate and sheets: *Sir Lewis Jones.* Industrial Wales: future of the South Wales ports: *Leslie E. Ford.*

Economica—

May 1947—Malayan rubber politics: *P. T. Bauer.* Complementarity and substitution in the theory of capital: *L. M. Lachmann.* Some observations on Professor Lange's analysis: *Vittoria Marrama.* The marginal cost controversy: a reply: *J. A. Nordin.* The marginal cost controversy: some further comments: *R. H. Coase.*

Economic Journal—

December 1946—Deliberate industrialization for higher incomes: *N. S. Buchanan.* Economic models with special reference to Mr. Kaldor's system: *J. R. N. Stone* and *E. F. Jackson.* The social security movement in India: *A. N. Agarwala.* National and local finance: *Ursula K. Hicks.*

London and Cambridge Economic Service—

May 1947—Output of building and civil engineering industries.

Oxford University Institute of Statistics, Bulletin—

February 1947—The coal shortage: *D. Seers.* Economic prospects in Sweden: *E. Lundberg.* Reconstruction in Europe: *H. Frankel.*

March, April 1947—Critique of the Economic Survey: *D. G. Champernowne.* Britain in transition: *F. A. Burchardt* and *G. D. N. Worswick.* The charter of international trade: *T. Balogh.*

May 1947—The coal shortage: *D. Seers.* Working class income and household expenditure: *T. Schulz.*

Quarterly Journal of the Royal Meteorological Society—

October 1946—On periods and symmetry points in pressure as aids to forecasting: *Sir Gilbert Walker.*

Transactions of the Faculty of Actuaries—

Vol. XVII, Part II—The Actuary's tool-kit: *R. G. Deas.*

Vol. XVIII, Part IV—Some thoughts on the actuarial profession: *Sir A. Carr-Saunders.* Integral equations: some applications to actuarial science: *L. Solomon.*

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INDIA—

Sankhyā—

March 1947—Mathematical theory of the symmetrical factorial design: *R. C. Bose.* Parametric relations in multivariate distributions: *P. K. Bose.* A mathematical set-up leading to analysis of a class of designs: *H. K. Nandi.* A note on critical angles between two flats in hyperspace with certain statistical applications: *S. N. Roy.* On a statistical test of treatment effect on certain diseases: *M. N. Ghosh* and *S. N. Roy.* World War II and the consumption pattern of the Calcutta middle-class: *S. Bhattacharyya.*

UNION OF SOUTH AFRICA—

South African Journal of Economics—

December 1946—The Keynesian revolution in economics: *G. W. G. Browne.* The chemical industry in South Africa—before Union (1910): *H. Schauder.* Some comments on secondary industry in South Africa: *R. L. Threlfall.*

UNITED STATES—

American Academy of Political and Social Science, Annals—

March 1947—Communication and social action. (Whole number.)
May 1947—Women's opportunities and responsibilities. (Whole number.)

American Economic Review—

March 1947—The economist and the State: *E. A. Goldenweiser.* The prospect for economic growth: *C. R. Noyes.* Expansion and employment: *E. D. Domar.* Determinants of distribution of income: *M. A. Copeland.* Postscript on war inflation: *W. J. Fellner.* The International Bank: *Nathaniel Weyl* and *M. J. Wasserman.* German finance in World War II: *R. W. Lindholm.*

American Statistical Association, Journal—

March 1947—A tribute to two past presidents of the Association: *Isador Lubin.* Social and economic adjustments in a democratic world: *Isador Lubin.* The United States government program for statistics: articles by *Earl Constantine, William H. England, Philip M. Hauser, A. F. Hinrichs, G. A. Lamb* and *Conrad Taeuber.* Problems of multiple-punching with Hollerith machines: *Kurt Benjamin.* An empirical approach to economic intelligence in World War II: *Richard Ruggles* and *Henry Brodie.* Grant-in-aid apportionate formulas: *Francis G. Cornell.* Methods of measuring the marginal propensity to consume: *Trygve Haavelmo.* A critique of "A method for making actuarial estimates for a compulsory health insurance system": *R. J. Myers.*

Annals of Mathematical Statistics—

March 1947—The general canonical correlation distribution: *M. S. Bartlett.* On the Theory of Markoff Chains: *Elliott W. Montroll.* On the first two moments of the measure of a random set: *L. A. Santaló.* On a test of whether one of two random variables is stochastically larger than the other: *H. B. Mann* and *D. R. Whitney.* On the convergence of sequences of moment generating functions: *W. Kozakiewicz.* A generalization of Tshebyshev's inequality to two dimensions: *Z. W. Birnbaum, J. Raymond* and *H. S. Zuckerman.* Distribution of the serial correlation coefficient in a circularly correlated universe: *R. B. Leipnik.* Concerning the effect of intraclass correlation on certain significance tests: *John E. Walsh.* On families of admissible tests: *E. L. Lehmann.* Conditional expectation and unbiased sequential estimation: *David Blackwell.* The distribution of the mean: *E. L. Welker.*

Bell System Technical Journal—

April 1947—Probability functions for the modulus and angle of the normal complex variate: *Ray S. Hoyt.*

Biometrics—

March 1947—Some consequences when the assumptions for the analysis of variance are not satisfied: *W. G. Cochran.* The use of transformations: *M. S. Bartlett.*
June 1947—The analysis of covariance method for the relation between a part and the whole: *R. A. Fisher.* 2×2 factorial experiments in incomplete groups for use in biological assays: *C. I. Bliss.* Statistical treatment of counts of trichostrongylid eggs: *L. Otis Emik.*

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Econometrica—

April 1947—Irving Fisher at eighty: *Ragnar Frisch.* Response to Professor Frisch: *Irving Fisher.* Mathematical economists and others: a plea for communicability: *J. M. Clark.* Statistical analysis of the demand for food: examples of simultaneous estimation of structural equations: *M. A. Girshick* and *Trygve Haavelmo.* The use of econometric models as a guide to economic policy: *Lawrence R. Klein.*

Harvard Business Review—

Spring 1947—A forecast of business prospects: *F. D. Newbury.* Accuracy of government statistics: *Geoffrey H. Moore.* New England's decline in the American economy: *Seymour E. Harris.* Federal support for scientific research: *W. Rupert Maclaurin.*

Journal of Political Economy—

February 1947—International cartel policy: *Bert F. Hoselitz.* Australia's central bank: *J. S. G. Wilson.* The budget approach to wage adjustments—a case study: *Jules Backman.*

April 1947—International finance in the post-war world: *Jacob Viner.* Theories of effective demand and employment: *Lawrence R. Klein.* What was wrong in forecasts of post-war depression?: *W. S. Woytinsky.*

Mathematical Tables and other Aids to Computation—

April 1947—A symposium of large scale digital calculating machinery.

Milbank Memorial Fund Quarterly—

April 1947—European migrations: pre-war trends and future prospects: *Dudley Kirk.* Possibilities and limits of international control of migration: *Carter Goodrich.* The present status of our immigration laws and policies: *E. P. Hutchinson.* The demographic and economic implications of larger immigration: *Warren E. Thompson.* Recent refugee immigration from Europe: *Maurice R. Davie.* Recent trends of rural-urban migration in the United States: *Conrad Taeuber.*

Quarterly Journal of Economics—

February 1947—Multiple-plant firms, cartels and imperfect competition: *Don Patinkin.* Regulation of minimum rates in transportation: *Truman C. Bigham.* The mortgage portfolio of mutual savings banks: *Paul M. Gregory.* Forward shifting of a payroll tax under monopolistic competition: *Sam Arnold.* The volume of foreign trade and the level of income: *Wolfgang F. Stolper.*

May 1947—The fallacies of Lord Keynes' general theory: *Jacques Rueff.* The British balance of payments and problems of domestic policy: *Alfred E. Kahn.* Some problems in the explanation of interest rates: *J. Tinbergen.* The British imperial preference system: *David L. Glickman.* Industrial development of the near east: *Bernard D. Weinryb.*

Review of Economic Statistics—

May 1947—Two discussions of the Employment Act of 1946 and its early operations: *Alvin H. Hansen* and *Jacob Viner.* American agriculture: Schultz' analysis and policy proposals: *Joseph S. Davis.* The reconversion period: reflections of a forecaster: *Everett E. Hagen.* Wages and prices—a case study: *Harold H. Wein.*

CZECHOSLOVAKIA—

Statistick Obzorý (Czech text, Russian, English and French summaries)—Vol. XXVII, Part I—Statistical studies in Czechoslovakia: *Prof. Dr. Jaroslav.* Dissection of frequency curves: *Dr. František Egermayer.* Some relations between factor-analysis and the theory of multiple and partial correlation: *Dr. O. Fischer.*

FRANCE—

Journal de la Société de Statistique de Paris—

March-April 1947—Rapports du Trésorier et de la Commission des Fonds et Archives: La paix monétaire et le problème européen-rhénan: *Lucien Coquet.* Chronique de statistique sociale: *Jacques Lehoulier.* Sur l'interprétation du coefficient de corrélation: *M.-V. Musham.*

May-June 1947—Salariat et productivité: *Jean Duvallet.* Le groupage des observations et les corrections qu'il nécessite dans le calcul des moments: *Maurice Dumas.* Valeur de la preuve en dactyloscopie: *Lucien Amy.*

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Population—

January-March 1947—Guerre et population: *Paul Vincent.* L'enfant et la famille devant l'impôt: *Alfred Sauvy.* La population féminine active en France et à l'étranger: *Jean Daric.* La population allemande: situation actuelle et perspectives: *Sully Ledermann.* Caractéristiques démographiques du Brésil contemporain: *Jacques Lambert.*

Revue d'Économie Politique—

January-February 1947—Les erreurs de la théorie générale de Lord Keynes: *Jacques Rueff.* La théorie de l'inflation a la lumière des expériences monétaires contemporaines: *Bertrand Nogaro.* Les principaux courants de la pensée économique suédoise contemporaine: *André Marchal.* Deux expressions statistiques de la réalité sociale: le total et la moyenne: *Jean Lhomme.*

ITALY—

Giornale degli Economisti e Annali di Economia—

January-February 1947—Coerenza e stabilità nella condotta economica razionale: *V. Dominedò.* I limiti economici delle nazionalizzazioni: *G. di Nardi.* Sulla relazione tra gli indici alfa e delta: *M. de Vergottini.* Note di statistica economica: *G. Tagliacarne.* Sul metodo matematico in economia: *R. Maggi.* Ancora in merito ad una osservazione critica del Pareto: *A. de Toma A-Gambino.*

INTERNATIONAL—

International Labour Review—

January-February 1947—The Belgian social security scheme: *Paul Goldschmidt.* Reconversion and reconstruction in the U.S.S.R.: *A. Yugow.*

March-April 1947—The housing problem in France: *Alfred Sauvy.* Social Insurance in the Soviet Union.

May 1947—Allied policy on wages in Occupied Germany: *Matthew Kelly.*

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LIST OF ADDITIONS TO THE LIBRARY

Since the issue of Part IV, 1946, the Society has received the publications enumerated below.

I.—OFFICIAL PUBLICATIONS

(a) United Kingdom

Agriculture and Fisheries, Ministry of, etc. Agricultural statistics 1939–1944. United Kingdom, Part I, with separate figures for England and Wales, Scotland, Great Britain, and Northern Ireland. London: H.M.S.O., 1947. 53 pp. 9¾″. 1*s.*

Colonial Office.

The Colonial Empire (1939–1947). London: H.M.S.O., 1947. iv, 124 pp. 2*s.* 6*d.*

The Colonial Office list 1946, comprising historical and statistical information respecting the colonial empire, lists of officers serving in the colonies, etc., and other information. First edition. (Colonial 205.) London: H.M.S.O., 1946. vii, 344 pp. 8½″. 10*s.* 6*d.*

Development and welfare in the West Indies 1945–46: report by Sir John Macpherson. (Colonial 212.) London: H.M.S.O., 1947. 162 pp. 9¾″. 3*s.*

Economic survey for 1947. London: H.M.S.O., 1947. Cmd. 7046. 36 pp. 9¾″. 6*d.*

Electricity Commission. War period report of the Electricity Commissioners. Twentieth report covering the six years April 1, 1939, to March 31, 1945, inclusive. London: H.M.S.O., 1946. 199 pp. 10¾″. 10*s.*

Food, Ministry of.

Food consumption levels in United Kingdom. London: H.M.S.O., 1947. Cmd. 7203. 18 pp. 9¾″. 6*d.*

Manual of nutrition 1947. London: H.M.S.O., 1947. iv, 64 pp. 9¾″. 1*s.*

Fuel and Power, Ministry of. Supplement to *Statistical Digest* 1945, containing regional and district coal production figures. London: H.M.S.O., 1947. 131 pp. 9¾″. 2*s.* 6*d.*

General Register Office.

The Registrar-General's decennial supplement, England and Wales, 1931. Part IV, Multiple or secondary causes of death. London: H.M.S.O., 1947. iv, 192 pp. 13″. 12*s.* 6*d.*

Studies on Medical and Population Subjects. I. Regional and local differences in cancer death rates, by Percy Stocks. London: H.M.S.O., 1947. [2], 46 pp. 9¾″. 1*s.*

Health, Ministry of. Report of the Ministry of Health for the year ended March 31, 1946, including the Report of the Chief Medical Officer on the state of the public health for the year ended December 31, 1945. London: H.M.S.O., 1947. Cmd. 7119. vi, 194 pp. 3*s.* 6*d.*

Labour and National Service, Ministry of.

Interim index of retail prices: a short explanatory note. London: H.M.S.O., 1947. 7 pp. 9¾″. 2*d.*

Statement on the economic considerations affecting relations between employers and workers. London: H.M.S.O., 1947. Cmd. 7018. 9 pp. 2*d.*

Medical Research Council. Special Report Series 257. A study of individual children's diets, by E. M. Widdowson. London: H.M.S.O., 1947. vii, 196 pp. 9¾″. 6*s.*

Scottish Education Department.

Primary education: a report of the Advisory Council on Education in Scotland. 1946. Cmd. 6973. vii, 140 pp. 9¾″. 2*s.* 6*d.*

Secondary education: a report of the Advisory Council on Education in Scotland. 1947. Cmd. 7005. vi, 198 pp. 9¾″. 3*s.* Edinburgh: H.M.S.O., 1946–7.

Supply, Ministry of. Directorate of Royal Ordnance Factories. Explosives. Industrial experimentation. 2nd ed., by K. A. Brownlee. London: H.M.S.O., 1947. 151 pp. 9¾″. 2*s.* 6*d.*

Town and Country Planning, Ministry of. Northumberland and Tyneside: a bibliography by W. C. Donkin and E. F. Patterson. London: H.M.S.O., 1946. xvi, 101 pp. 7¾″. 2*s.* 6*d.*

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Trade, Board of.
Report of the British goodwill trade mission to Iraq, Syria, The Lebanon, and Cyprus. London: H.M.S.O., 1946. 68 pp. maps. 9¾″. 2*s.*
Working Party reports. Heavy clothing. 1947. 208 pp. 3*s.* 6*d.* Lace. 1947. 163 pp. 3*s.* 6*d.* Linoleum and felt base. 1947. viii, 49, charts. 1*s.* 6*d.* Wool. 1947. vii, 231 pp. 3*s.* 6*d.* London: H.M.S.O., 4 vols. 9¾″.

Treasury. Machines and appliances in government offices. London: H.M.S.O., 1947. 68 pp. 11″. 5*s.*

Works, Ministry of.
Cement costs: report by the committee appointed by the Ministry of Works. London: H.M.S.O., 1947. 30 pp. 9¾″. 9*d.*
Labour requirements in the brick industry. First report of the technical committee of the National Brick Advisory Council. London: H.M.S.O., 1947. 21 pp. 9¾″. 4*d.*
National Brick Advisory Council. Paper one. The getting of clay, with special reference to labour requirements, by H. H. Macey and A. T. Green. 1947. 34 pp. 9*d.* Paper two. The labour involved in the making and firing of common bricks, and a summary of the total labour requirements of brickmaking, by H. H. Macey and A. T. Green. 1947. 60 pp. 1*s.* London: H.M.S.O. 9¾″.
Technical notes and papers. T.N. 52. M.S.1. An extension of the statistical concept of marginal distribution, by D. M. Hannah and J. S. Arthur. 7 pp. T.N. 53. M.S.2. Stresses in a rod subjected to dynamical forces, by N. J. Durant. 6 pp. T.N. 54. M.S.3. The statistical behaviour of sums of dependent variables, by N. H. Carrier and J. S. Arthur. 4 pp. T.N. 55. M.S. 4. Oscillations of a spring-mounted foundation, by N. J. Durant. 6 pp. London, 1946. 4 papers. Stencilled. 13″.

(b) Other National and International Publications

Bulgaria.

Direction Générale de la Statistique.
Statistique des salaires ouvriers dans les entreprises industrielles 1941–1945. Sofia, 1946. 4, 109 pp. 12″.
Statistique du commerce extérieur 1942–1944. Sofia, 1946. xliv, 239 pp. 12¾″.

Canada.

Department of Reconstruction and Supply.
Forecast of 1947 investment by Canadian business. Ottawa, 1947. 39 pp. 9¾″.
Production of basic and building materials in Canada: outlook 1947. Ottawa, 1947. 22 pp. 9¾″.
Research and scientific activity: Canadian federal expenditures 1938–1946. Ottawa, 1947. 48 pp. 9¾″.

Egypt.

Département de la Statistique Générale. Annuaire statistique de poche 1946. Cairo, 1946. 94, 392, 6 pp. 5½″.

Eire.

Department of Industry and Commerce. Ireland. Census of population 1946. Preliminary report. Dublin: Stationery Office, 1946. 26 pp. 10″. 9*d.*

Finland.

Bureau Central de Statistique. Suomen tilastollingen vuosikirja, xlii. 1944–45. Annuaire statistique de Finlande. Helsingfors, 1946. xxii, 368 pp. 11½″.

France.

Institut National de la Statistique et des Études Économiques.
Code alphabétique des métiers et des activités individuelles. Paris, 1947. 278 pp. 10¾″.
Enquêtes diverses sur les prix et les consommations de 1942 à 1944. Paris, 1947. 164 pp. 10½″.

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Nomenclature analytique des métiers et des activités individuelles. Paris, 1947. xii, 308 pp. $10\frac{1}{2}''$.

Nomenclature des entreprises, établissements et toutes activités collectives. Index alphabétique. 317 pp. Index analytique. 222 pp. Paris, 1947. 2 vols. $10\frac{3}{4}''$.

International Labour Office.

Nutrition in industry. (Studies and Reports, N.S. 4.) Montreal, 1947 (London: Staples Press). ii, 177 pp. 4*s*.

League of Nations.

Economic Financial and Transit Department. Europe's population in the interwar years, by Dudley Kirk (1946, II, A, 8). Geneva, 1946 (London: Allen & Unwin). xii, 307 pp. $10\frac{1}{2}''$.

Poland.

Główny Urzad Statystyczny.

Powszechny sumaryczny spis ludnosci z dn. 14 II 1946 r. General summarized population census on Feb. 14, 1946 (Statystyka Polski D. 1). Warsaw, 1947. xvi, 108 pp. $11\frac{1}{2}''$.

Statystyka zakladów przemyslowych zatrudniajacych 5 i wiçcej pracowników 1946. Statistics of industrial plants employing 5 and more workers 1946 (Statystyka Polski D. 2). Warsaw, 1947. xi, 24 pp. $11\frac{1}{2}''$.

Spiz zakladów przemyslowych 1945. Census of industrial plants 1945 (Statystyka Polski D. 3). Warsaw, 1947. xii, 104 pp. $11\frac{1}{2}''$.

Switzerland.

Bureau Fédéral de Statistique.

Eidgenössische Steuerverwaltung. Eidg. Wehrsteuer III Periode Eidg. Wehropfer 1945. Kanton Obwalden. 1946. 45 pp. (S.S.172) Kanton Uri. 1947. 45 pp. (S.S. 175) Kanton Appenzell I.Rh. 1947. 45 pp. (S.S. 180) Kanton Luzern. 1947. 76 pp. (S.S. 182) Bern, 1946-47. 4 vols. $11\frac{3}{4}''$.

Exploitations agricoles par systèmes d'utilisation du sol et genres d'entreprises 1939. (S.S. 168.) Bern, 1946. 136, 105 pp. $11\frac{3}{4}''$.

Office Fédéral des Assurances Sociales. Caisses-maladie suisses et caisses d'assurance contre la tuberculose 1938–1943. (S.S. 176.) Bern, 1946. iv, 65, 14 pp. $11\frac{3}{4}''$.

Recensement fédéral de la population 1er decembre 1941. 15. Kantone Uri, Schyz, Unterwalden ob und nid dem Wald. 330 pp. (S.S. 167.) 17. Cantone Ticino. 154 pp. (S.S. 170.) 18. Kanton St. Gallen. (S.S. 178.) 197 pp. 19. Kanton Schaffhausen. 102 pp. (S.S. 181.) Bern, 1947. 4 vols. $11\frac{3}{4}''$.

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United States of America.

Bureau of the Census. A chapter in population sampling, by the Sampling Staff, Bureau of the Census. Washington, Supt. of Documents, 1947. v, 141 pp. 9″. $1.

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II.—AUTHORS AND MISCELLANEOUS

ALLEN (EDWARD S.), *editor*. Six-place tables: a selection of tables of squares, cubes, square roots, cube roots, fifth roots and powers, circumferences and areas of circles, common logarithms of numbers and of the trigonometric functions, and the natural logarithms, exponential and hyperbolic functions, and integrals; with explanatory notes by Edward S. Allen. 7th ed. New York and London: McGraw-Hill, 1947. xxiii, 232 pp. 7″. 12*s*. 6*d*.

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ARLEY (NIELS). On the theory of stochastic processes and their application to the theory of cosmic radiation. Copenhagen: G. E. C. Gads Forlag, 1943. 240 pp. 9¾″.

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BOREL (ÉMILE), *editor*. Traité du calcul des probabilités . . . Tome I. Les principes de la théorie des probabilités. Fasc. II. Erreurs et moindres carrés, par R. Deltheil. 1930 [8], 161 pp. 120*f*. Tome II. Les applications de la théorie des probabilités aux sciences mathématiques et aux sciences physiques. Fasc. I. Applications à l'arithmétique et à la théorie des fonctions . . . par Émile Borel . . . 1926 [3], 102 pp. 10″. 120*f*. Fasc. II. Probabilités géométriques par R. Deltheil. 1926 [4], 123 pp. 10″. 120*f*. Fasc. III. Méchanique statistique classique . . . par Émile Borel . . . 1925 [5], 148 pp. 10″. 120*f*. Fasc. IV. Applications de la théorie des probabilités à l'astronomie par C. E. V. Charlier. 1931. xi, 181 pp. 10″. 175*f*. Fasc. V. Méchanique statistique quantique par Francis Perrin. 1939. [5], 224 pp. 10″. 300*f*. Tome III. Les applications de la théorie des probabilités aux sciences économiques et aux sciences biologiques. Fasc. I. Assurances sur la vie. Calcul des primes, par Henri Galbrun, 1924 [5], 311 pp. 9½″. 175*f*. Fasc. II. Assurances sur la vie. Calcul des réserves, par Henri Galbrun. 1927 [6], 290 pp. 9½″. 150*f*. Fasc. III. Applications de la statistique à la démographie et à la biologie, par R. Risser. 1932, x, 255 pp. 10″. 200 *f*. Fasc. IV. Théorie mathématique de l'assurance-invalidité et de l'assurance-nuptialité. Définitions et relations fondamentales, par Henri Galbrun. 1935 [5], 156 pp. 10″. 150*f*. Fasc. V. Calcul des primes et des réserves, par Henri Galbrun. 1933, viii, 183 pp. 10″. 200*f*. Fasc. VI. Théorie mathématique de l'assurance-maladie par Henri Galbrun. 1934, viii, 230 pp. 10″. 250*f*. Tome IV. Applications diverses et conclusions. Fasc. I. Applications au tir, par J. Haag. 1926, vi, 183 pp. 10″. 150*f*. Fasc. II. Applications aux jeux de hasard . . . par Émile Borel. 1938, xi, 122 pp. 10″. 200*f*. Fasc. III. Valeur pratique et philosophie des probabilités, par Émile Borel. 1939, ix, 182 pp. 10″. 250*f*. Paris: Gauthier-Villars, 1925–1939. 15 vols.

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DUPRIEZ (LEON H.). Des mouvements économiques généraux. Louvain: Institut de Recherches Economiques et Sociales, 1947. 2 vols. 9¾″. 250*f.* (Presented by the author.)

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FINNEY (D. J.). Probit analysis: a statistical treatment of the sigmoid response curve . . . with a foreword by F. Tattersfield. Cambridge University Press, 1947. xiii, 256 pp. 8½″. 18*s.*

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FREEMAN (H. A.). Industrial statistics: statistical technique applied to problems in industrial research and quality control. New York: John Wiley, 1946 (London, Chapman & Hall). ix, 178 pp. 9″. 16*s.* 6*d.*

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INDIAN SOCIETY OF AGRICULTURAL ECONOMICS. Agrarian reforms in western countries. Bombay: Vora & Co., 1946. 122 pp. 9¾″. *Rs.* 3.

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KENNEY (JOHN F.). Mathematics of statistics. Part one. 2nd ed. New York: Van Nostrand Co., 1947. (London: Macmillan.) xii, 260 pp. 9″. 21*s.*

KERRICH (J. E.). An experimental introduction to the theory of probability. Copenhagen: Einer Munksgaard, 1946. 98 pp. 9¾″. *Kr.* 8.50.

KUCZYNSKI (ROBERT R.). The measurement of population growth: methods and results. London: Sidgwick & Jackson, 1935. vi, 255 pp. 8½″. 12*s.* 6*d.*

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LERNER (ABBA P.). The economics of control; principles of welfare economics. New York: Macmillan, 1946. xxiv, 428 pp. 8¼″. 21*s*.

LÉVY (PAUL). Théorie de l'addition des variables aléatoires. (Monographies des Probabilités, Fasc. 1.) Paris: Gauthier-Villars, 1937. xvii, 238 pp. 24*s*.

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REGISTRATION OF THE UNITED KINGDOM

No. I.—ENGLAND AND WALES

BIRTHS, DEATHS, *and* MARRIAGES *registered in the Calendar years* 1942–1946 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age; rate per* 1,000 *Live Births registered in the same year. Stillbirths per* 1,000 *Births.)*

Years	1942		1943†		1944†		1945†		1946†	
Estimated Mid-year Popln. in thousands‡	41,897		42,143		42,449		42,636		42,850	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	654,039	*15·6*	683,212	*16·2*	744,843	*17·5*	685,273	*16·1*	820,268	*19·1*
Stillbirths	22,335	*33*	21,275	*30*	21,212	*28*	19,451	*28*	22,844	*27*
Deaths [1]	480,137	*11·5*	501,412	*11·9*	492,176	*11·6*	488,108	*11·4*	491,759	*11·5*
Marriages	369,744†	*8·8*	296,432	*7·0*	302,714	*7·1*	397,626	*9·3*	382,969	*8·9*
Infant Mortality [2] ...	32,258	*49*	33,432	*49*	33,456	*45*	31,961	*47*	33,413	*41*
Effective reproductive rate [3]	*0·853*		*0·900*		*0·996*		*0·909*		*1·102*	
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–Mar.	158,225	*15·3*	172,271	*16·6*	183,973	*17·4*	177,946	*16·7*	181,445	*16·9*
Apr.–June	167,611	*16·0*	180,709	*17·2*	199,039	*18·9*	175,221	*16·4*	203,797	*19·0*
July–Sept.	168,335	*15·9*	169,306	*15·9*	183,594	*17·2*	167,807	*15·7*	213,135	*19·9*
Oct.–Dec.	159,868	*15·1*	160,926	*15·1*	178,237	*16·7*	164,299	*15·4*	221,891	*20·7*
	Stillbirths									
Jan.–Mar.	5,652	*34*	5,783	*32*	5,587	*29*	5,190	*28*	5,178	*28*
Apr.–June	5,787	*33*	5,577	*30*	5,496	*27*	4,853	*27*	5,764	*28*
July–Sept.	5,437	*31*	4,980	*29*	5,018	*27*	4,676	*27*	5,778	*26*
Oct.–Dec.	5,459	*33*	4,935	*30*	5,111	*28*	4,732	*28*	6,124	*27*
	Deaths [1] (excluding Stillbirths)									
Jan.–Mar.	151,262	*14·6*	137,578	*13·2*	146,039	*13·8*	157,743	*14·8*	155,153	*14·5*
Apr.–June	116,937	*11·2*	112,912	*10·7*	115,548	*10·9*	110,972	*10·4*	114,070	*10·6*
July–Sept.	97,336	*9·2*	98,474	*9·3*	107,254	*10·1*	97,157	*9·1*	100,363	*9·4*
Oct.–Dec.	114,602	*10·9*	152,448	*14·4*	123,335	*11·6*	122,236	*11·5*	122,173	*11·4*
	Marriages									
Jan.–Mar.	88,280	*8·4*	62,684	*6·0*	62,879	*5·9*	76,975	*7·2*	77,480	*7·2*
Apr.–June	100,992	*9·6*	82,577	*7·8*	82,583	*7·8*	99,709	*9·4*	100,814	*9·4*
July–Sept.	96,445	*9·2*	81,569	*7·7*	82,312	*7·7*	119,447	*11·2*	109,047	*10·2*
Oct.–Dec.	84,027	*8·0*	69,602	*6·6*	74,940	*7·0*	101,495	*9·5*	95,628	*8·9*
	Infant Mortality [2]									
Jan.–Mar.	9,697	*61*	9,914	*60*	10,104	*58*	10,656	*60*	9,598	*53*
Apr.–June	7,820	*47*	8,028	*46*	7,936	*43*	7,201	*41*	7,624	*37*
July–Sept.	6,766	*40*	6,771	*40*	7,325	*40*	6,412	*38*	7,052	*33*
Oct.–Dec.	7,713	*48*	8,370	*51*	7,862	*44*	7,588	*46*	9,139	*41*

* All rates are based on the estimated population as at the middle of the corresponding year.
† Provisional figures.
‡ Inclusive of non-civilians of England and Wales temporarily abroad; and exclusive of non-civilians of Foreign Countries, Dominions, etc., temporarily in England and Wales.
[1] Including deaths of non-civilians registered in England and Wales.
[2] The annual figures have been corrected, so that slight differences appear between them and the aggregates of the quarterly figures.
[3] Based not upon current, but upon estimated future mortality.

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No. II.—SCOTLAND

BIRTHS, DEATHS, *and* MARRIAGES *registered in the Calendar years* 1942–1946 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age; rate per* 1,000 *Live Births. Stillbirths per* 1,000 *Births.)*

Years	1942		1943		1941		1945†		1946†	
Estimated Mid-year Popln. in thousands‡	4,751		4,662		4,654		4,640		4,933	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	90,697	*17·6*	94,682	*18·4*	95,941	*18·5*	86,932	*16·9*	104,406	*20·3*
Stillbirths	3,602	*38*	3,494	*36*	3,221	*32*	2,949	*33*	3,470	*32*
Deaths [1]	64,963	*13·3*	66,733	*14·0*	64,603	*13·6*	62,655	*13·2*	64,605	*13·1*
Marriages	47,402	*9·2*	38,177	*7·4*	37,111	*7·2*	18,728	*9·4*	45,831	*8·9*
Infant Mortality	6,283	*69*	6,174	*65*	6,237	*65*	4,889	*56*	5,621	*54*
Quarters	**Live Births in the Quarters of each Calendar Year**									
Jan.–Mar.	21,885	*17·3*	23,277	*18·3*	23,231	*18·0*	21,644	*16·9*	22,909	*18·1*
Apr.–June	24,142	*18·8*	25,439	*19·8*	25,618	*19·9*	22,579	*17·6*	25,849	*20·2*
July–Sept.	22,586	*17·4*	23,320	*17·9*	23,405	*17·9*	21,341	*16·4*	27,031	*20·9*
Oct.–Dec.	22,084	*17·0*	22,646	*17·4*	23,687	*18·2*	21,365	*16·5*	28,617	*22·1*
	Stillbirths									
Jan.–Mar.	970	*42*	940	*39*	816	*34*	746	*33*	808	*34*
Apr.–June	931	*37*	886	*34*	874	*33*	774	*33*	860	*32*
July–Sept.	835	*36*	825	*34*	751	*31*	671	*30*	850	*30*
Oct.–Dec.	866	*38*	843	*36*	780	*32*	758	*34*	952	*32*
	Deaths (excluding Stillbirths)									
Jan.–Mar.	19,444	*16·3*	17,746	*15·1*	17,988	*15·2*	18,674	*16·0*	19,741	*16·3*
Apr.–June	16,298	*13·4*	15,874	*13·3*	15,288	*12·9*	15,364	*13·0*	15,185	*12·2*
July–Sept.	13,783	*11·2*	14,243	*11·8*	14,745	*12·3*	13,082	*10·9*	13,594	*10·8*
Oct.–Dec.	15,438	*12·6*	18,870	*15·8*	16,582	*13·9*	15,535	*12·9*	16,085	*12·7*
	Marriages									
Jan.–Mar.	12,710	*10·0*	9,267	*7·2*	9,043	*7·0*	9,764	*7·6*	9,981	*7·9*
Apr.–June	12,209	*9·5*	9,697	*7·6*	9,266	*7·2*	12,384	*9·6*	11,478	*9·0*
July–Sept.	11,888	*9·2*	10,203	*7·9*	9,872	*7·6*	13,646	*10·5*	12,851	*9·9*
Oct.–Dec.	10,595	*8·2*	9,010	*7·0*	8,930	*6·8*	12,934	*10·0*	11,521	*8·9*
	Infant Mortality									
Jan.–Mar.	1,960	*90*	1,756	*75*	1,756	*76*	1,465	*68*	1,579	*69*
Apr.–June	1,544	*64*	1,479	*58*	1,462	*57*	1,234	*55*	1,221	*47*
July–Sept.	1,322	*59*	1,283	*55*	1,510	*65*	979	*46*	1,222	*45*
Oct.–Dec.	1,457	*66*	1,656	*73*	1,509	*64*	1,211	*57*	1,599	*56*

* Death rates are based on civilian population and civilian deaths; birth and marriage rates on total population (including persons in the forces).
† Provisional figures.
‡ Civilians only.
[1] Registered deaths, civilians and non-civilians.

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No. III.—NORTHERN IRELAND

BIRTHS, DEATHS, *and* MARRIAGES *registered in the Calendar years* 1942–1946 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age; rate per* 1,000 *Live Births.)*

Years	1942		1943		1944		1945†		1946†	
Estimated Mid-year Popln. in thousands‡	1,296		1,304		1,314		1,319		1,332	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	29,645	*22·9*	31,521	*24·2*	30,900	*23·5*	29,007	*22·0*	30,135	*22·6*
Stillbirths [1]					Not registered					
Deaths‡	17,256	*13·3*	17,437	*13·4*	16,791	*12·8*	16,264	*12·3*	16,666	*12·5*
Marriages	11,673	*9·0*	10,155	*7·8*	9,508	*7·2*	10,452	*7·92*	9,671	*7·3*
Infant Mortality [2]	2,265	*76*	2,464	*78*	2,083	*67*	1,975	*68*	1,619	*54*
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–Mar.	6,731	*20·8*	7,907	*24·3*	7,612	*23·2*	7,335	*22·2*	7,278	*21·9*
Apr.–June	7,987	*24·7*	8,695	*26·7*	8,312	*25·3*	7,509	*22·8*	7,925	*23·8*
July–Sept.	7,834	*24·2*	7,738	*23·7*	7,503	*22·8*	7,189	*21·8*	7,646	*22·9*
Oct.–Dec.	7,093	*21·9*	7,181	*22·0*	7,473	*22·7*	6,978	*21·1*	7,287	*21·8*
	Deaths‡ (excluding Stillbirths)									
Jan.–Mar.	5,168	*16·0*	4,890	*15·0*	5,108	*15·5*	5,249	*15·9*	5,435	*16·4*
Apr.–June	4,287	*13·2*	4,335	*13·3*	4,072	*12·4*	3,962	*12·0*	4,026	*12·1*
July–Sept.	3,639	*11·2*	3,642	*11·2*	3,483	*10·6*	3,339	*10·1*	3,280	*9·8*
Oct.–Dec.	4,162	*12·8*	4,570	*14·0*	4,128	*12·6*	3,714	*11·2*	3,925	*11·8*
	Marriages									
Jan.–Mar.	2,466	*7·6*	2,318	*7·1*	2,044	*6·2*	2,131	*6·5*	2,200	*6·6*
Apr.–June	3,190	*9·8*	2,628	*8·1*	2,532	*7·7*	2,786	*8·5*	2,484	*7·5*
July–Sept.	3,396	*10·5*	2,904	*8·9*	2,646	*8·1*	2,980	*9·0*	2,767	*8·3*
Oct.–Dec.	2,621	*8·1*	2,305	*7·1*	2,286	*7·0*	2,520	*7·6*	2,220	*6·7*
	Infant Mortality [2]									
Jan.–Mar.	652	*97*	676	*85*	650	*85*	700	*95*	464	*64*
Apr.–June	569	*71*	647	*74*	501	*60*	504	*67*	436	*55*
July–Sept.	511	*65*	589	*76*	420	*56*	384	*53*	331	*43*
Oct.–Dec.	527	*74*	546	*76*	508	*68*	382	*55*	388	*53*

* Rates are based on civilian population only.
† Provisional figures.
‡ Civilians only.
[1] Stillbirths are not registered in Northern Ireland. The births of one living child and one stillborn, or one living child and two stillborn, is counted as one birth.
[2] The annual figures have been corrected, so that slight differences appear between them and the aggregates of the quarterly figures.

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No. IV.—EIRE

BIRTHS, DEATHS, *and* MARRIAGES *registered in the Calendar years* 1942–1946 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age; rate per* 1,000 *Live Births.)*

Years	1942		1943		1944		1945†		1946†	
Estimated Mid-year Popln. in thousands	2,963		2,946		2,944		2,983		2,992	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	66,117	*22·3*	64,375	*21·9*	65,425	*22·2*	66,861	*22·4*	67,547	*22·6*
Stillbirths‡					Not registered					
Deaths	41,640	*14·1*	43,494	*14·8*	45,128	*15·3*	42,762	*14·3*	41,455	*13·9*
Marriages	17,470	*5·9*	17,328	*5·9*	16,772	*5·7*	17,301	*5·8*	17,575	*5·9*
Infant Mortality ...	4,591	*69*	5,310	*83*	5,198	*79*	4,739	*71*	4,261	*63*
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–Mar.	14,427	*19·5*	16,400	*22·3*	17,066	*23·2*	16,073	*21·6*	16,855	*22·5*
Apr.–June	18,181	*24·5*	16,916	*23·0*	17,663	*24·0*	17,940	*24·1*	18,045	*24·1*
July–Sept.	17,749	*24·0*	16,242	*22·1*	15,749	*21·4*	17,244	*23·1*	17,163	*22·9*
Oct.–Dec.	15,760	*21·3*	14,817	*20·1*	14,947	*20·3*	15,604	*20·9*	15,484	*20·7*
	Deaths (excluding Stillbirths)									
Jan.–Mar.	12,122	*16·4*	12,627	*17·1*	14,814	*20·1*	13,715	*18·4*	13,026	*17·4*
Apr.–June	10,822	*14·6*	10,974	*14·9*	11,074	*15·0*	10,754	*14·4*	10,534	*14·1*
July–Sept.	8,497	*11·5*	8,955	*12·2*	8,785	*11·9*	8,892	*11·9*	8,567	*11·5*
Oct.–Dec.	10,199	*13·8*	10,938	*14·9*	10,455	*14·2*	9,401	*12·6*	9,328	*12·5*
	Marriages									
Jan.–Mar.	4,013	*5·4*	4,548	*6·2*	4,222	*5·7*	3,697	*5·0*	4,480	*6·0*
Apr.–June	4,603	*6·2*	4,006	*5·4*	4,069	*5·5*	4,594	*6·2*	4,115	*5·5*
July–Sept.	5,021	*6·8*	5,132	*7·0*	4,599	*6·2*	4,928	*6·6*	5,203	*7·0*
Oct.–Dec.	3,833	*5·2*	3,642	*4·9*	3,882	*5·3*	4,082	*5·5*	3,777	*5·0*
	Infant Mortality									
Jan.–Mar.	1,163	*81*	1,583	*97*	1,719	*101*	1,486	*92*	1,367	*81*
Apr.–June	1,149	*63*	1,304	*77*	1,241	*70*	1,097	*61*	1,020	*57*
July–Sept.	1,031	*58*	1,186	*73*	1,021	*65*	1,032	*60*	920	*54*
Oct.–Dec.	1,248	*79*	1,246	*84*	1,217	*81*	1,124	*72*	954	*62*

* Rates are based on the total estimated population as at the middle of the corresponding year.
† Provisional figures.
‡ Stillbirths are not registered in Eire. The births of one living child and one stillborn, or one living child and two stillborn, is counted as one birth.

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Journal of the Royal Statistical Society

PART III, 1947

The Statistical Basis of Export Targets

[A Discussion before the Royal Statistical Society, March 27th, 1947, The President, The Rt. Hon. Lord Woolton, P.C., C.H., in the Chair]

Opened by Dr. E. C. Snow, C.B.E.

(1) The first reference in official publications to an export target for this country of which I am aware was in certain paragraphs of the White Paper Cmd. 6707—"Statistical material presented during the Washington negotiations"—relating to the United States loan to this country in the autumn of 1945. Those paragraphs were:

> "11. It is estimated that the increase in the volume of exports over the pre-war level, which will be necessary to pay for the pre-war volume of imports after allowing for the decline in other sources of external earnings, is of the order of 50 per cent. Something more than this will, however, be necessary to reach and maintain full equilibrium, for the above calculation makes no allowance for the following factors:
>
> "(i) By the end of the transitional period more than ten to fifteen years will have elapsed since the dates taken as the pre-war standard of reference (years 1936–1938). During this period the number of adults and separate families in the U.K. will have increased appreciably. Moreover, it is expected that the standard of output and efficiency which will have been reached should bring some improvement in the standard of life and some increase in the level of industrial production, with a consequent increase in the demand for imports of all kinds. Thus, in the absence of restrictive measures of the type which it is hoped to avoid, it is likely, and indeed obviously desirable, that the volume of imports will tend to exceed the pre-war level.
>
> "(ii) No provision has been included for the repayment of war and post-war debts.
>
> "(iii) No provision has been included for the working capital to allow credit to foreign purchasers or for other expenditure overseas inevitably required in the course of building up a great volume of new trade.
>
> "12. It may be, therefore, that the full restoration of a reliable equilibrium, which can persist without measures of restriction or the other defensive mechanisms of the type with which it is hoped to dispense, may require a volume of exports nearer 75 per cent. than 50 per cent. in excess of the pre-war level."

(2) It will be noted that the Washington target was designed to enable us to import and pay not only for approximately the same quantity of food, raw material and manufactured goods that we imported on the average annually over 1936/38, but to allow also for the increase in population, for some improvement in the standard of living, for the repayment of war and post-war debts, and for building up working capital for the purpose of giving credit to foreign purchasers. It will be useful to have a formula or set of formulae which will give us fairly readily some idea of the export target to be aimed at for the attainment of each of the various stages in rehabilitation referred to. In other words, what will be the index of volume of exports required to attain various levels of importation which we may assume, allowing for our invisible exports and imports and on the assumption that we pay our way. The simplest case to enquire about is—what level of exports will be required so that our consumption of imported goods may be at the same level as pre-war?

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(3) I take as the basic period that used in the Washington memorandum, namely, 1936–38; Appendix 7 of the memorandum sets out the U.K. balance of payments over that period. The same matter has been dealt with in the recent "Economic Survey for 1947," but the statistical approach has been modified by taking our figures of imports at f.o.b. prices and not at c.i.f. as has been general hitherto. This means some adjustment in the "invisible" items to allow for the difference between imports f.o.b. and imports c.i.f. It is necessary for me to follow the lines of the Washington memorandum rather than of the Economic Survey, in view of the fact that the splitting up of imports and exports into the three main groupings is essential. For shortness I shall refer to the splitting up of imports and exports into—

(i) food, drink and tobacco,
(ii) raw materials and articles mainly unmanufactured,
(iii) articles wholly or mainly manufactured,

as Class I, Class II and Class III respectively. Class IV—animals not for food—and Class V—parcel post—have been included with Class III. Class IV is almost infinitesimal, and Class V naturally falls into Class III.

The average annual figures of imports and exports over 1936–38 on this basis are as follows:

	Net Imports.		*Exports.*
	million £		
Class I	401·9	.	36·8
Class II	237·0	.	57·6
Class III	227·1	.	382·9
Total . .	866·0	.	477·3

(4) The procedure will be to find the index for exports in Class III for some indefinite post-war year, which I will refer to as *X*, on the basis of various assumptions. The method of approach will be illustrated in the case where we assume the same volume of imports of (*a*) food and (*b*) materials *for consumption in this country* that we had in the basic period. A large number of targets can be determined for this objective according to the various other assumptions which have to be made regarding the factors involved in the problem. The chief of these are:

(i) What will be the price level in period *X* compared with the basis period for (*a*) imports and (*b*) exports?

(ii) What will be the values of the "invisible" items in the balance of payment statement?

(iii) What will be the proportion of imports involved in producing the articles we export? It will be apparent that to aim at importing the same quantity of materials as we did before the war will not be sufficient to give us (*a*) the quantity which we require to produce manufactured goods for consumption in this country plus (*b*) the *increased* quantity which we shall require to increase our export trade in manufactured goods. Some assumptions as to what is the proportion of imported materials involved in producing manufactured articles, therefore, will be necessary.

(5) With regard to (i)—price levels—the Washington memorandum was based on 100 per cent. increase above 1936–38, both for imports and exports. Over the past eighteen months the average value of imports has increased at a greater rate than has that of exports. Moreover, divergence may develop between the movements in the levels for Class I, Class II and Class III respectively, both for imports and exports. The movements since 1945 have been as set out below.

Throughout 1946 the rate of advance of average values for imports was greater than that of exports. The Washington estimate was based upon the index of 200 both for imports and exports, but for the fourth quarter of 1946 the import values were about 15 per cent. higher than the export —indices of approximately 230 and 200. Following the increase in price of many primary products which has taken place in recent months, it is to be expected that for at least the first two quarters of 1947 and probably longer the disparity will become even greater. On the other hand, the experience between the wars indicated that when a general movement downward in prices occurs, the price index for exports does not fall so sharply as does that of imports. (See diagram.) I will refer to the matter again later when the effect of this disparity on the target has been indicated.

(6) With regard to the second assumption referred to in (4)—relating to invisible imports and exports—the recent Economic Survey provides most up-to-date information, though more

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Index Numbers of Average Values.

Imports.

	1945	1946 1st Qtr.	1946 2nd Qtr.	1946 3rd Qtr.	1946 4th Qtr.
			1938 = 100		
Class I	185	200	214	221	236
Class II	213	209	211	217	236
Class III	216	181	194	184	213
All Classes	198	195	206	209	228

Exports.

	1945 4th Qtr.	1946 1st Qtr.	1946 2nd Qtr.	1946 3rd Qtr.	1946 4th Qtr.
			1938 = 100		
Class I	190	195	199	212	198
Class II	215	203	212	205	211
Class III	183	184	189	194	203
All Classes	186	186	191	196	203

will be available next month. After setting out an import programme for 1947 on the basis of f.o.b. prices, the Survey says:

> "70. There are other claims upon our foreign exchange resources. The expenditure abroad of the Armed Forces; our share of the cost of Germany; expenditure on relief; advances for rehabilitation; grants for Colonial development and welfare—all these, like imports, must be paid for by exports. Likewise, Government receipts from claims arising out of the war, sales of surplus military stores abroad, etc., earn us foreign exchange. The excess of Government overseas expenditure over Government receipts from overseas may be of the order of £175 millions in 1947, but much of the expenditure and receipts depends upon happenings throughout the world which are outside the control of the Government; any figure is therefore a very broad estimate at this stage.
>
> "71. We expect to have to find in all some £1625 millions of foreign exchange in 1947 —£1450 millions for imports and £175 millions for net overseas Government expenditure. This must be covered by our exports and re-exports, by our invisible income, or by borrowing from abroad. For reasons explained below, the Government considers that it would be unsafe to plan in 1947 to borrow more than £350 millions net. Our net invisible income may yield £75 millions. This leaves £1200 millions to be provided by receipts from exports and re-exports."

The Economic Survey indicates for 1947 invisible exports of £75 million to set off against invisible imports of £175 million, excluding borrowing of £350 million. To make the former figure comparable with that of the Washington memorandum it is necessary to take into account some portion of the excess of imports c.i.f. over imports f.o.b. The Survey stated that the f.o.b. value of our gross imports in 1946 was £1100 million. The Board of Trade return indicated the c.i.f. value at practically £1300 million.

How much of the difference of £200 million is really an "invisible export" it will require an expert on shipping accountancy to say. As a by-product of exchange control probably some reliable information on this point (as on other points connected with invisible imports and exports) may be forthcoming in due course. I attach a statement summarizing the Board of Trade Estimates of Balance of Payments from 1924 to 1938. My method of approach to the export target problem requires that an estimate of some sort should be made for the figure in the last column for year *X*. The column "Net Government receipts from overseas," which was unimportant before the war, will make a substantial negative contribution, though to suggest now what the figure may be will be guess-work.

(7) The third assumption referred to in (4) above—what will be the proportion of imports involved in producing the articles we export?—is an important one. When we export an article like cotton yarn, the raw material for which is entirely imported and the process of manufacture involved is in value proportionately not very great, it is clear that the net foreign exchange earned by the export—taking the imported material into account—is not large in proportion to the turn-

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over of the transaction. This represents an instance at one end of the range. At the other end the case of exports of pottery may be mentioned. Here the proportion of imported material involved in the product exported is small, and the net foreign exchange earned in the transaction will be a very high proportion of the gross value of the export. We want to get an idea of what the proportion is averaged over all the many articles and materials exported. Some light was thrown upon this in a paper published in 1931 (*J.R.S.S.*, **94**, Part III, pp. 406 *et seq*). The investigation there described, however, was based upon data of the Census of Production of 1924. There has been a considerable change in the character of our export trade since then. In 1924 cotton manufacturers accounted for 32 per cent. of our total exports, while machinery plus vehicles (two articles in which the proportion of imported materials in the finished product exported is below the average of all articles exported) accounted for 11 per cent. In 1946 cotton manufactures accounted for 7 per cent. only and machinery plus vehicles for 25 per cent. In 1938 the proportions were 11 per cent. and 22 per cent. respectively. It seems fairly certain that the proportion of imported materials involved in our total exports of manufactured goods at the present time is less than it was before the war. It would be a very complex job indeed to find out the true figure, and in the calculations below the pre-war figure is taken at 20 per cent. and the post-war one at 15 per cent.

(8) On the basis of any particular proportion, e.g. 20 per cent., we can ascertain how much of the total imported materials are used for subsequent export and how much for home consumption. Over 1936–38 our exports of manufactured goods averaged £383 million annually which, on the basis of 20 per cent., involved the use of £77 million of imported materials. This £77 million of materials is measured at the port of exportation and has undergone two journeys between port and factory (and some of it other journeys between two or more factories). I will take the value at place of original importation as 20 per cent. less than at the subsequent place of exportation, i.e. £62 million.

The total imported materials annually over the basic period were £464 million, made up of £237 million of Class II—"Raw materials and articles mainly unmanufactured"—and £227 million of Class III—"Articles wholly or mainly manufactured." It is necessary to bring the latter as well as the former item into account since it contains semi-manufactures from which articles are manufactured for export as well as manufactured goods ready for consumption.* (In the period in question, for example, a substantial proportion of the finished leather and some proportion of the leather manufactures exported was made from partially manufactured leather imported under the Class III heading.) The aggregate import figure of £464 million can therefore be divided into two parts—(*a*) £62 million for use in articles to be exported and £402 million for articles to be consumed in this country, a proportion of less than one to six. In the relatively stable conditions of 1936–38 it was satisfactory to take the import figure for one year against the appropriate export figure for the same year. In a more rapidly expanding period such as the present it is clearly not so satisfactory. If the same calculations are made on the 1946 figures (exports of manufactured goods £786 million, total of net imports of Class II and Class III £595 million) on the basis of 15 per cent. we shall have of this £595 million about £95 million (£118 million when measured at time of exportation) for use in producing articles to be exported and £500 million for articles to be consumed here—a proportion of about one to five. This is a higher proportion than pre-war, but the time lag between imports and subsequent exports of articles made from those imports is more important in a period of expansion such as 1946 was than in the pre-war period. Moreover, we deliberately stimulated our exports in 1946 at the expense of home consumption. The imports in 1946 of Class III contained only a small proportion of goods ready for consumption. The index number of volume of retained imports of all articles in the 21 groups in Class III in 1946 was 57 (1938 = 100). Of the 11 groups containing mostly articles ready for consumption the index was only 30, but for the remaining 10 groups, containing mainly articles for further processing, it was 67. Under these circumstances we should expect the proportion of imports to be used for exportation, compared with imports for consumption, to be higher in 1946 than in 1938. The proportion of one to five mentioned above for 1946, therefore, is probably in good accordance with the proportion of one to six for 1938. The pro-

* If the nature of the problem justified further precision we could separate the goods ready for consumption from the rest in Class III. In 1938 the former constituted about one-quarter of the total, and in 1946 about one-fifth, and it did not, of course, enter into subsequent export trade.

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portions for the three years 1935, 1936 and 1937 were about the same. I think, therefore, that I am not overstating the importance of imported materials in subsequent exports by the assumption I have made.

(9) Although our ultimate objective is to ascertain a target for the total of our exports—Classes I, II and III together—we are going to reach this by finding first a target for Class III alone. It is accordingly necessary to make some assumptions regarding the level of exports for the two relatively small items, Class I and Class II. In the aggregate these two classes in 1946 accounted for just over 10 per cent. of the total exports; but in the last quarter of the year for less than 9 per cent. The indices of volume of exports for Class I were 88 for the whole year 1946, and 79 for the last quarter; for Class II they were 28 and 30 respectively. I will take the figure of 80 for Class I and 30 for Class II for year *X*. Moderate variations from these figures will not make much difference in the final result.

(10) The procedure for making the necessary calculations can now be set out for one set of assumptions. The modifications at various points for other assumptions will be clear. I will illustrate the case in which—

(i) import values in year *X* are 120 per cent. above pre-war;

(ii) export values in year *X* are 100 per cent. above pre-war.

Examine first the items on the export side of the figures in paragraph (3) above:

(*a*) Class I: The pre-war figure was £37 million. In year *X*, on the assumption of double price, the same quantity would be valued at £74 million. But we only propose to export 80 per cent. of the pre-war volume, so that the value in year *X* will be £59 million.

(*b*) Class II: Pre-war imports were £58 million. In year *X* the same quantity would be valued at £116 million. But we only propose to export 30 per cent. of the pre-war volume, so that the value in year *X* will be £35 million.

(*c*) Class III: Pre-war figure was £383 million. At double price for year *X* the value for the same volume will be £766 million. But the actual volume will be $\frac{x}{100}$ of pre-war (where x is the index of volume we have to find), so that the value in year *X* will be $766 \cdot \frac{x}{100}$.

Thus, the total exports in year *X* will be

$$94 + 766 \cdot \frac{x}{100}.$$

On the import side the corresponding analysis is—

(*a*) Class I: Pre-war import was £402 million. With an increase of 120 per cent. in price and the same volume as before the war, the value in year *X* will be £884 million.

(*b*) Class II and Class III taken together. These totalled pre-war £464 million and consisted of (i) materials for subsequent manufacture and export, which I will refer to as M_E, and (ii) materials for use for home consumption, referred to as M_C. Paragraph 8 indicated a value of £62 million for M_E and £402 million for M_C. To obtain the same volume for the latter in year *X* at price 120 per cent. above pre-war, the value will require to be £884 million. The value of the materials to be imported for making up for export in year *X* will be 15 per cent. of the $766 \cdot \frac{x}{100}$ (which is the value of the Class III export item above) less the double port to factory charges (paragraph 8), and will therefore be 80 per cent. of $115 \cdot \frac{x}{100}$.

Thus the total imports in year *X* will be—

$$884 + 884 + 92 \cdot \frac{x}{100}.$$

We therefore get the equation—

$$1768 + 92 \cdot \frac{x}{100} = 94 + 766 \cdot \frac{x}{100} + I,$$

where I represents the excess of invisible exports over invisible imports. This leads to—

$$\frac{x}{100} = 2{\cdot}48 - \frac{I}{674}.$$

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When an index has been determined for Class III exports it is a simple matter to deduce the corresponding index for all exports (on the basis of the indices of 80 and 30 for Classes I and II, the index for all classes taken together is $9{\cdot}8 + {\cdot}80x$).

For various values of net invisible exports (in £ million) the following are the indices (rounded off to the nearest 5) for (*a*) Class III exports alone, and (*b*) all exports:

Case I. Average price of imports 120 per cent above pre-war.
Average price of exports 100 per cent. above pre-war.

Net invisible exports (£ million)	—50	0	50	100	150	200	250	300
(*a*) Index for Class III	255	250	240	235	225	220	210	200
(*b*) Index for all exports	215	210	200	195	190	185	180	170

If we assume a particular figure for the net invisible exports in year *X*, say, £150 million, then on the other assumptions made—the chief of which is that the average value of imports will be 120 per cent. above pre-war and of exports 100 per cent. above pre-war—to obtain the pre-war volume of imports of food and of materials to be consumed in this country, exports as a whole will require to be 90 per cent. in volume above pre-war, which will necessitate the volume of exports of manufactured goods being 125 per cent. above pre-war.

(11) I have worked out corresponding indices for a number of other sets of assumptions regarding changes in price level, but otherwise retaining the same assumptions as in paragraph (10):

Case II. Average price of imports 100 per cent. above pre-war.
Average price of exports 100 per cent. above pre-war.

Net invisible exports (£ million)	—50	0	50	100	150	200	250	300
(*a*) Index for Class III	235	225	215	210	200	195	185	180
(*b*) Index for all exports	200	190	180	175	170	165	160	155

Case III. Average price of imports 100 per cent. above pre-war.
Average price of exports 120 per cent. above pre-war.

Net invisible exports (£ million)	—50	0	50	100	150	200	250	300
(*a*) Index for Class III	205	200	195	190	180	175	170	165
(*b*) Index for all exports	175	170	165	160	155	150	145	140

Case IV. Average price of imports 60 per cent. above pre-war.
Average price of exports 50 per cent. above pre-war.

Net invisible exports (£ million)	—50	0	50	100	150	200	250	300
(*a*) Index for Class III	250	240	230	220	210	200	190	180
(*b*) Index for all exports	210	200	195	185	180	170	160	155

Case V. Average price of imports 50 per cent. above pre-war.
Average price of exports 50 per cent. above pre-war.

Net invisible exports (£ million)	—50	0	50	100	150	200	250	300
(*a*) Index for Class III	235	225	215	205	195	185	175	165
(*b*) Index for all exports	200	190	180	170	165	160	150	140

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Case VI. Average price of imports 50 per cent. above pre-war.
Average price of exports 60 per cent. above pre-war.

Net invisible exports (£ million)	−50	0	50	100	150	200	250	300
(*a*) Index for Class III .	220	210	200	190	180	170	160	155
(*b*) Index for all exports	185	180	170	160	155	145	140	135

Case VII. Average price of imports 150 per cent. above pre-war.
Average price of exports 120 per cent. above pre-war.

Net invisible exports (£ million)	−50	0	50	100	150	200	250	300
(*a*) Index for Class III .	260	255	250	245	235	230	225	215
(*b*) Index for all exports	220	215	210	205	200	195	190	180

(12) The answers to other cases which readily suggest themselves can be worked out in the same way. For example, if the problem is—what is the index required if we aim at importing 90 per cent. of our pre-war level of food but 110 per cent. of our pre-war level of raw materials for consumption in this country? On the basis of average value of imports 120 per cent. above pre-war and of exports 100 per cent. above pre-war the answer is $\frac{x}{100} = 2{\cdot}50 - \frac{I}{674}$ The index will range from 255 for I = −50 to 205 for I = 300.

Another case is—what level of imports could we obtain on the basis of a target for all exports of 175? This figure for all exports requires that the target for manufactured goods should be 206. On the same assumptions regarding price increases as above, the answer is $\cdot 84 + \frac{I}{1768}$ ranging from 80 per cent. for I = −50 to 100 per cent. for I = 300.

(13) The most favourable price circumstances which can develop will be those in which the excess above pre-war for exports is higher than for imports. For a particular value of the invisible export item, say, £150 million, in the first comparison (Cases I, II and III) the Class III index is 225 if the advance in import average values is 20 points higher than in export average values, but is only 180 if the reverse is the case. In the second comparison (Cases IV, V and VI), where the general advance is only half as great, the corresponding figures are 210 and 180. As exports will have to be sold to a large extent against competition, we cannot help ourselves to any appreciable amount through deliberate contrivance at higher export prices. The benefit from the consideration mentioned will have to come, if at all, from lower import prices—mainly, that is, of food and raw materials. The future of the movements of these prices is certainly a very important and intriguing subject. It may well be that concentration of effort to keep prices low in 1946 will not ultimately be judged the best way of attempting to get low import prices over an extended period a few years hence. Stimulation of production, if necessary by a phase of high prices, has always in the past proved itself an effective means of obtaining lower prices in due course. Concentration on the idea of stable prices *at a time when production is insufficient* fails to give that stimulus which creates increased output, which should be the primary objective. The history of the index numbers of values of imports and exports over the critical period of 1929–32 is instructive and is indicated on the attached diagram in which, on the basis of 1930 = 100, the indices are traced over the period 1924 to 1938. On this basis, for some years before 1929, import prices were relatively higher than those of exports. They fell, however, to a much greater extent, and for some years after 1931 were relatively well below export values. (The greater part of the fall occurred before we went off the Gold Standard in September, 1931.) The bad effects of wide price fluctuations are well known, but the upward movements of them do stimulate production. To attempt to avoid those evils by a too rigid policy of price stability may produce the even greater evil of scarcity. A comprehensive study of price policy and its effects since the end of the war would be very instructive.

(14) In view of the considerable uncertainty which must for some time exist regarding the two

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most important factors involved in determining the target—the price level for imports and exports and the value of the net invisible exports—it is clearly impossible to form a fairly precise opinion as to what level of exports we shall require in order to obtain the imports we need and to pay our way. We can get some idea of what will be needed if things go badly for us, and on the other hand, we can get a corresponding indication of what will be required if factors turn out favourable. The former alternative will be experienced if circumstances similar to those of Case VII come about—in which average price of imports is as much as 150 per cent. above pre-war, while of exports it is only 120 per cent. above—and we have to continue to meet heavy Government expenditure abroad without being able to increase appreciably our gross invisible exports. The value of I then may be small. Even if we take it at £150 million, a level of total exports 100 per cent. above pre-war (requiring a level of 135 per cent. above pre-war for manufactured goods) would then be required to import on the pre-war level and pay our way. More would be required to cover the additional matters mentioned in the Washington memorandum. The favourable alternative would be experienced if the circumstances turned out to be somewhat similar to Case III—in which average price of imports is only 100 per cent. above pre-war, while of exports it is 120 per cent. above—and if we substantially reduce our overseas Government expenditure while improving on our gross invisible exports. We might then have a value of I of, say, £300 million (the pre-war value was about £350 million). Then we could obtain the pre-war level of imports and pay our way on a level of exports over all of about 40 per cent. above pre-war, involving an increase for manufactured goods of about 65 per cent. above pre-war. Each of us can have his own choice of assumptions in a problem like this. My own view is that it is unduly optimistic to think that matters will turn out so favourable as to enable us to get back to our pre-war level of imports by a 75 per cent. increase in exports. If our objective is to import sufficient to enable us to maintain the pre-war level of consumption of imported articles, I consider that it would be better to think in terms of a target 100 per cent. above pre-war for all exports, which, unless we can export substantial quantities of coal, requires one of about 140 per cent. above pre-war for exports of manufactured goods.

(15) Whether it is or is not possible, in the industrial circumstances of this country and of the rest of the world, to attain such a level is a separate subject deserving of much consideration. German exports, excluding deliveries on account of reparations, advanced by 87 per cent. in the five years following 1924, during which period ours advanced by only 8 per cent. However, it must be borne in mind that Germany in 1924 was well below the pre-war level. The great advance she made between 1924 and 1930 was achieved not merely by hard and sustained effort, but also by much complicated currency manipulation. Though it is to be hoped that we shall put forward an effort of equal magnitude, we shall not follow Germany's path in currency manipulation. We shall no doubt get some help from the international trade and financial organizations now set up. At the best, however, it will be a long time before the deliberations about to take place at Geneva on reductions of tariff barriers bear sufficient fruit to make a substantial change in our situation. This help cannot be looked upon as alternative to the personal effort which must be embarked upon to reduce costs of production, in order to be able to sell our products abroad in competition with the growing production of other countries. In the autumn of last year we were inclined to some complacency over our economic position, owing to the fairly rapid increase in our exports which was then showing; had we then had similar information of other countries' progress, we should have known that there was no justification for such complacency. A number of countries have not yet re-started publishing monthly statistics of foreign trade, but what is known of progress in other countries affords little evidence that we are doing more than just to hold our own in competition for markets overseas. Statistical comparison in these matters is difficult at present and must for some time be of a scrappy character. An illustration of the extent to which competition will have to be faced is afforded by examining the figures of the exports from (*a*) this country and (*b*) the United States to Argentine and Brazil, two countries which have made very great progress in industrialization over recent years, and to which we are most anxious to export our manufactured goods. The U.S.A. also exports to those countries mainly manufactured goods. The figures of American exports between the fourth quarter of 1945 and the third quarter of 1946 advanced from £20 million to £32 million. Our figures advanced from £2·8 million to £9·4 million. Although we show a much greater rate of progress, our exports to these two countries have only been one-third of those of the U.S.A. recently, and clearly, if we are to make more headway

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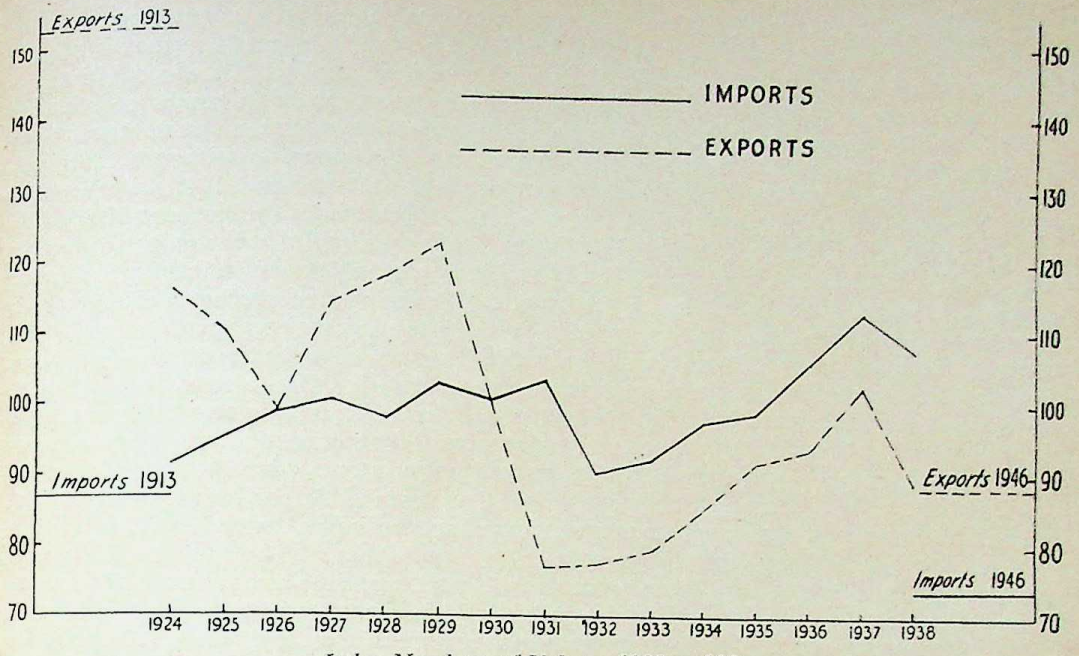
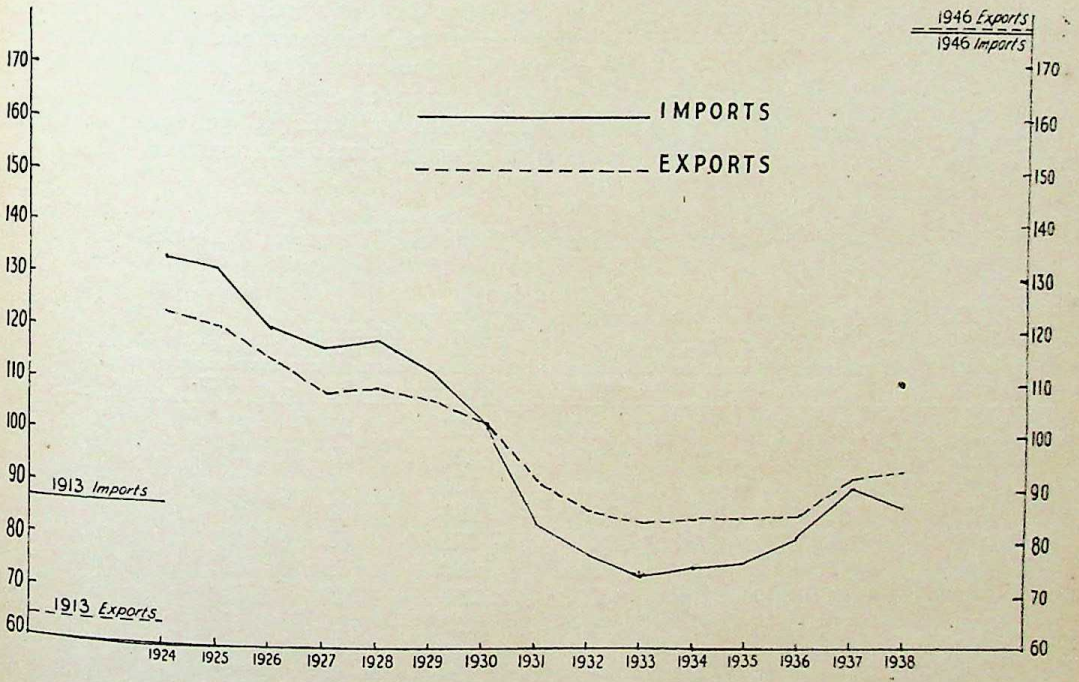


Index Numbers of Volume 1930 = 100.



Index Numbers of Average Values 1930 = 100.

in these very important markets, we have to ensure that we can sell at least as cheaply as the U.S.A. producers can.

(16) I feel more interested at present in trying to assess the likelihood of obtaining even a modest increase in the present level of our exports than in the somewhat academic statistica

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exercise of working out figures for targets on various assumptions. The export target referred to in the Economic Survey of 140 per cent. of 1938 by the end of this year (it represents a figure of 160 per cent. for manufactured goods) looks modest enough in the light of the level of imports it would enable us to obtain; but a detailed study of the figures for the 21 groups of industries included in Class III (articles wholly or mainly manufactured) indicates clearly that it cannot be obtained without very substantial contributions from two of the groups—machinery and vehicles. These two alone accounted for 35 per cent. of the exports in the last quarter of 1946, and when their figures are combined their progress in the four quarters last year was in the sequence 84, 116, 131 and 160 respectively, while the corresponding figures for the aggregate of the remaining 19 groups were 93, 107, 111 and 114 respectively. While machinery and vehicle exports almost doubled in volume, the whole of the remainder of the exports of manufactured goods advanced by only 23 per cent. There is a limit, however, to which it is safe to stimulate exports of the products of these two industrial groups without risking serious injury to the other 19 from which some fairly substantial contribution to increased exports must be obtained. The figure of 140 per cent. mentioned in the Economic Survey for the end of 1947 is approximately that which would be reached for the fourth quarter of the year if the sequence for the second, third and fourth quarters of 1946–98—104 and 111—were continued for a further four quarters. It is very doubtful, however, if we could have proceeded along these lines even had the recent industrial dislocation not occurred. To achieve it under existing circumstances seems improbable unless we can rapidly devise a means of increasing production and decreasing costs.

The adoption of some index for an export target, based upon the assumption that we are to import sufficient to maintain a particular standard of life, naturally suggests that there should also be a production target. This would provide a measure of the output needed to supply the finished goods required for (*a*) the standard aimed at, plus (*b*) the particular level of exports denoted by the export target. This, in turn, might lead to a "working hours" target, providing a rough measure of the increase in working time above the basic period required to turn out the goods indicated by the production target. But more and more assumptions would be needed at each stage. We should also require to know the relation between production and exports at the present time, and in the absence of an up-to-date census of production, this would involve some dubious estimates. Perhaps someone whose notions on "planning" go farther than mine might be able to put before the Society some calculations on these further matters.

Summary of Board of Trade Estimates of Balance of Payments, 1923–1938

£ (million)

Year.	Excess of Imports.	Net Government receipts from overseas.	Net shipping income.	Net investment income.	Net receipts from commissions, etc.	Net receipts from other sources.	Total of items specified.
1923	195	—25	133	200	30	10	348
1924	324	—25	140	220	60	15	410
1925	384	—11	124	250	60	15	438
1926	475	4	120	285	60	15	484
1927	390	1	140	285	63	15	504
1928	358	15	130	270	65	15	495
1929	381	24	130	250	65	15	484
1930	386	19	105	220	55	15	414
1931	408	14	80	170	30	10	304
1932	287	—24	70	150	25	15	236
1933	263	—2	65	160	30	10	263
1934	294	7	70	170	30	10	287
1935	261	—2	70	185	30	10	293
1936	345	—3	85	200	35	10	327
1937	442	—4	130	210	40	10	386
1938	377	—13	100	200	35	..	322

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Mr. R. GLENDAY: Dr. Snow deserves congratulation for introducing this discussion for two especial reasons: first, for reading a paper on what is certainly the most important economic issue facing our country to-day, and second, on finding a forum for the discussion where those taking a less favourable view of our prospects than is generally current, may ventilate their ideas without incurring the odium of becoming involved in political controversy or accusations of promoting pessimism and depression. This raises what I regard as one of the most serious obstacles to the propagation of the truth facing our country to-day in the field of economic affairs. One is continually reading articles or listening to speeches which conclude on an optimistic note, well knowing that their authors are far from happy regarding our prospects, but are fearful of saying so for the reasons given above. In this way, free and open discussion is stifled. One result, as we have seen in recent weeks, is that the country suddenly wakes up to find it has been overtaken by a crisis foreseen by many whose duty it is to study these matters, though not by the public generally. Had franker discussion been practicable, there would have been a more general realization of our plight, and so, I believe, much earlier steps could have been taken both to mitigate our difficulties and to avoid much suffering. I believe that for the same lack of plain speaking we are in danger of heading for a similar crisis in the export field.

Now Dr. Snow has made it, I think, quite clear that the so-called export targets are not "targets" in any real sense at all. They are simply the results of financial calculations in regard to the exchange needed to balance our international account. Dr. Snow has shown how unreal such targets can be when translated into terms of production, by examining them in the framework of our actual imports and exports statistics. Had he been given time, he might have taken the matter a stage further and also illustrated the unreality of export targets framed without regard to the long-term pattern of our commercial and financial relationships. To quote two examples. Our industrial system was founded on the basis of cheap and plentiful supplies of coal, and reliance on the export of some of that coal, either directly or indirectly, to obtain many of our essential import needs. If we had coal to export to-day, then we should not only be able to do much to alleviate raw material shortages such as the timber famine, which is holding up so many of our industrial activities to-day, but also greatly to accelerate the recovery of the continent of Europe. I mention this to illustrate that the *qualitative* aspect of our export trade may be more important from the long-term point of view than the quantitative.

My second example relates to another aspect of the qualitative side of our export problem. At the moment there is a sellers' market in which almost anything can be sold at almost any price. But this condition will not last. What are we doing to-day to prepare for the lean days which must inevitably overtake us to-morrow? Nothing. All that seems to matter is the global total of our exports *to-day*. That in the process we may be starving our industries of the re-equipment needs essential to their survival in the export field in the future is ignored. As a leader writer in *The Times* observed the other day: "One views with wry satisfaction the fact that the daily rate of our exports of machinery was higher in February than in any other month, apart from December of last year."

Most important of all, these quantitative calculations entirely ignore the world environment in which our export trade expansion has to be achieved—and maintained. I include in the term environment not only prospects in the more immediate future, but also the longer-term historical trend of international trade evolution as a whole.

In this connection I should like to refer to some of the considerations which led me as far back as 1943 to dismiss as chimerical the suggestion—as it then was—that it would be practicable in the years immediately following the war, by adopting the policy at present being pursued, to raise our export trade to some 50 per cent. above its 1938 volume—and hold it there. The only attempt to justify such a policy on practical grounds I have met is the argument that as, before the war, only some 15 per cent. of our national output was devoted to export trade, to increase this by 50 per cent. only involved the diversion of a paltry 7½ per cent. of our national output! Here we have another example of the quantitative fallacy as applied to trade problems. It is like arguing that because a man's heart represents only a small fraction of his total weight it is absurd to suggest that its breakdown would make any serious difference to his well-being, since a few square meals could more than make up the loss in weight!

Let me remind you that the problem of expanding our export trade is not a new one. For example, despite the most strenuous efforts made in the period immediately following the 1914–1918 World War to maintain and expand our export trade, it declined on the average both in volume and value right up to the outbreak of the World War 1939.

But that is not the end of the story, for at the same time the other main item in our balance of trade account on which we relied for the means to purchase imports was suffering an analogous fate. I refer to our foreign investment account. Its history was broadly as follows: In the middle of the nineteenth century we exported more than we imported and invested the balance.

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In the next phase we not only continued to add to the capital sum, but reinvested the interest due on the old. In the third phase we ceased to invest on balance, and began to bring back the interest in the form of food and other imports. Shortly before World War II we had reached the stage that not only were we bringing back the interest due, but had begun to find ourselves compelled to sell part of the capital to balance our international account. In short, our country as a going concern had started to go downhill well before the outbreak of war in 1939. The war has accelerated the process.

The above is the background against which our present export drive must be viewed. Let us be clear that the current mania for re-equipment does not hold the key to the way out. Its immediate effect is more likely to be to exacerbate the distortion of our war-distorted economy by contracting still further the labour force of our labour-starved consumer goods industries, not to promote a balanced export trade.

This brings me to another misconception, namely, the popular view that the decline in our export trade after 1918 was primarily due to inefficiency. I am not saying this simply to defend British industry, but because it is important to realize what the true causes of that decline were, since they are likely to operate with renewed vigour in the years immediately ahead. The 1914–1918 War compelled our overseas markets either to look elsewhere for supplies, or manufacture their own. The industries established or expanded in this way claimed and received protection as soon as the British exporting industries were once again in a position to supply after that war. This change in market environment affected that home of mechanization and mass-production technique, the United States, almost as severely as ourselves. Sir Henry Clay has observed that "had the same industries as were depressed in the United Kingdom been concentrated in a single State—textiles, bituminous coal, shipping and shipbuilding—they would have provided a spectacle of depression equal to that of the Clyde or Tyne."* Few of the people who to-day comment on the unhappy state of such British industries as cotton and coal remember the primary cause of their disasters.

Now there is another feature of the long-term evolution trend still shaping our industrial destiny which is making escape from redundant industrial capacity even more difficult, and that is the change in the trend of economic evolution itself. In mature countries it is no longer a question of replacing old industries by new industries. New industries no longer emerge rapidly enough to offset the decline either in labour absorption or exporting capacity of the old. The trend of evolution, even before the war, was increasingly veering from industries, both home and export, to home services. In all the leading industrial countries you will find that before the War the proportion of people employed in the manufacturing industries was ceasing to expand, and I believe it is true to say that before 1939, even in the United States, the actual numbers employed in manufacturing industries were beginning to decline. Now it will be agreed by everyone who has studied the facts that the recent war has if anything accelerated all these long-term trends. Policies of industrial self-sufficiency have received far more active encouragement than during the last War, and for a much longer period; likewise the growing equalization of incomes is fostering the mass production of existing types of goods rather than the exploitation of new luxuries. These situations will be aggravated by the widespread over-expansion of war industries.

Remember that the epicentre of the great economic disaster which overtook the world at the close of 1929 was situated in the United States of America—the pioneer of mass production technique—and that one of its basic causes was the ability of America's gigantic industrial machine to produce goods more rapidly than they could be disposed of, for more than a short period, to her domestic consumers. That country remained in a state of almost continuous depression from 1929 to 1939, with the exception of a temporary upturn in 1937. I understand that to-day, although her capacity is not fully employed, her output is already one hundred and ninety per cent. of the average level of the years 1935 to 1939, and the purchasing power of her domestic consumers has failed to keep pace. As most of you will be aware, a slump of some kind is widely expected by American experts; by some as early as within a year from to-day. This may help us on the import side of our account, but not in the export field.

The above is a brief sketch of some of the leading features of the World environment in which this country is being expected to increase her exports above pre-war by something like 75 per cent. by volume—and hold it there. Frankly, I can find no precedent in history which warrants us in regarding the bridging of a gap of this magnitude in the short time at our disposal as a practical proposition. And I have said nothing about the obstacles created by our domestic shortages of labour, materials and fuel. Dr. Snow referred to the situation in Germany in 1924, but as he pointed out, there is no parallel: it was a period of recovery from a complete currency collapse, and when Germany did for a time regain her pre-war level she was unable to maintain

* "War on Unemployment." Barnett House Papers, No. 28.

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it. It is true that a policy of large-scale foreign investment would help us to make headway towards our objective once our domestic shortages were overcome. Unfortunately our foreign exchange situation precludes the use of this avenue of escape for many years to come. As it is, our recent export figures give an unduly optimistic picture of what has in fact been achieved up to date because indirectly we have been foreign investing by sending goods to countries who have been unable to pay for them—that is, providing on loan goods urgently needed to pay for immediate imports. Possibly as much as 20 per cent. of our export trade last year was dissipated in this way.

Our sole hope for the future, Dr. Snow suggests, lies in the setting up of the new international trade organization which is to be discussed at Geneva next week. But does anyone seriously believe that this organization can produce results quickly enough to save us? Remember Europe is still devastated, and the national production structures of a large number of other countries, including our own, are still in a state of acute dislocation. These are not situations that can be adjusted in a matter of months.

Now, I have mentioned the above depressing features, largely concealed from the general public for reasons with which I entirely sympathize, not because I wish to pose as a pessimist, but because I am uneasy regarding the outcome of this policy of concealment. Too many people have been encouraged to believe that our economic problem is, first, to revert as speedily as possible to our pre-war standard of living, but with more equal shares for all, and second, to see how quickly we can rise above that level. My own fear is that they may wake up one day to find that the real question calling for an urgent and immediate answer is: What can be done to prevent our standard of living from falling even below the low level at which it stands to-day, and remaining depressed for a longer period of years than any of us would care to contemplate?

Mr. M. G. KENDALL: I am sure the Meeting will join with Mr. Glenday in congratulating Dr. Snow in bringing before us to-night the important question of export targets. His analysis has done a great deal to clarify the position, and particularly to throw light on the various figures which are quoted officially as the appropriate export target for 1947 and subsequent years. What I should like to do in the short time I have is to consider the actual and prospective volume of invisible exports, with particular reference to shipping, but there are two small points in Dr. Snow's paper I would like to refer to in the first place.

(*a*) In paragraph 6, Dr. Snow refers to the fact that the economic survey gives the f.o.b. value of gross imports in 1946 as £1,100 millions, and that the Board of Trade return indicated a c.i.f. value at practically £1,300 millions. Dr. Snow proceeds to say that "how much of the difference of £200 millions is really 'an invisible export' it will require an expert on shipping accountancy to say." I am not an expert on shipping accountancy, but it seems to me that the whole of this £200 millions is to be included among invisible exports if one works on the basis which Dr. Snow has adopted, namely, the valuing of imports c.i.f. and the valuing of exports f.o.b. The point will perhaps be clearer from the explanation I give below of the nature of the shipping account.

(*b*) In paragraph 9, Dr. Snow assumes an index of 30 for class II exports in the year X. He therefore seems to accept the current opinion that class II exports will continue at a very low level. Class II exports, however, are very largely coal, and I see no reason why we should not look forward to a time when exports of coal on a substantial basis can be resumed. I admit that official pronouncements have given little encouragement to this view. This is perhaps politics rather than statistics, but it seems to me a most deplorable thing if the Government who, in the nature of things, are more optimistic than anybody else, assume that one of our major export industries can be completely written off, in spite of the fact that the country is effectively full of coal.

I now turn to the question of shipping earnings in their relation to the balance of payments. There is here a great source of possible misunderstanding. On the former basis exports were valued c.i.f. and imports f.o.b. The consequence was that the difference, called the "invisible balance," included freights on imports payable by British nationals to other British nationals. The "invisible balance" accordingly was not in fact a pure balance in the sense of being a balance of foreign exchange, but included quite a substantial amount which was a transfer between British nationals. Consequently the "net shipping income" was also inflated by that part of the freight on imports carried by British ships.

Now the new White Paper, as Dr. Snow has mentioned, has changed the basis, so that anyone who wants to compare any figures given in the White Paper or future Papers with the old figures must bear that in mind.

I show below a typical account for a pre-war year, namely 1936. I have worked on the year 1936 because that is the last year for which an enquiry was conducted into shipping earnings:

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TABLE 1

Balance of Income and Expenditure between the United Kingdom and Other Countries for 1936 *on the Old Basis (Imports f.o.b. and Exports c.i.f.)*

Expenditure	£ *million*	*Income*	£ *million*
Excess of imports of merchandise and bullion over exports	345	Estimated net shipping income	85
Estimated excess of Government payments overseas	3	Estimated net income from overseas investments	205
		Estimated net receipts from short interest, commission, etc.	30
		Estimated net receipts from other sources	10
		Balance	18
	348		348

Of the £85 million shown as the estimated net shipping income, about £10 million was the estimated net expenditure of foreigners in U.K. ports and about £75 million was the estimated net earnings of British shipping. This figure is a fair measure of the importance of British shipping, but it is not a measure of the earnings of foreign exchange, because about two-thirds of it represents payments made by British nationals to British nationals for the carriage of imports.

The recent White Paper breaks away from pre-War practice by computing both imports and exports f.o.b., and in consequence, the merchandise and bullion account becomes for the first time what it purports to be, a purely merchandise account. The White Paper does not commit itself to a shipping services account, but the logical consequence would be that an appropriate form of account would be in the form of Table 2 following:

TABLE 2

Suggested Form of Account for Shipping Services

Expenditure	*Income*
(*a*) Freight on imports carried in foreign vessels.	(*e*) Freight on exports in U.K. ships.
(*b*) Port expenditure of British ships in foreign ports.	(*f*) Freight on cross voyages.
(*c*) Passenger fares paid by U.K. nationals on foreign ships.	(*g*) Port expenditure of foreign vessels in U.K. ports.
(*d*) Balance.	(*h*) Fares paid by non-nationals on U.K. ships.

This account relates to the shipping services of the U.K. as a whole, that is to say it covers not only the earnings of the U.K. fleet, but also the payments made by the U.K. to foreign fleets for carriage on U.K. account. An appropriate form of account for the British fleet alone (a sub-account of Table 2) would be in the form of the following Table 3:

TABLE 3

Form of Account for U.K. Shipping Services

Expenditure	*Income*
(*b*) Port expenditure of British ships in foreign ports.	(*e*) Freight on exports in U.K. ships.
(*i*) Balance.	(*f*) Freight on cross voyages.
	(*h*) Fares paid by non-nationals on U.K. ships.

The last inquiry into shipping earnings was carried out by the Chamber of Shipping in respect of the year 1936, and on the basis of information provided by that inquiry it is possible to construct tentative accounts in the above forms for that year. These are shown in the following Tables 4 and 5:

TABLE 4

Shipping Services Account for 1936 *in the form of Table* 2. (*Some figures tentative*)

Expenditure	£ *million*	*Income*	£ *million*
(*a*) Freight on imports in foreign vessels	22·5	(*e*) Freight on exports in U.K. ships	25·6
(*b*) Port expenditure of U.K. ships in foreign ports	56·0	(*f*) Freight on cross voyages	41·7
(*c*) Passenger fares by U.K. nationals in foreign ships	7·0	(*g*) Port expenditure of foreign vessels in U.K. ports	17·0
(*d*) Balance	11·5	(*h*) Fares by non-nationals in British ships	12·7
	97·0		97·0

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TABLE 5

U.K. Shipping Services Account for 1936 *in the form of Table* 3. (*Some figures tentative*)

Expenditure	£ *million*	*Income*	£ *million*
(*b*) Port expenditure of U.K. ships in foreign ports	56·0	(*e*) Freight on exports in U.K. ships	25·6
(*i*) Balance	24·0	(*f*) Freight on cross voyages	41·7
		(*h*) Fares by non-nationals in British ships	12·7
	80·0		80·0

So far as concerns the contribution of shipping to the invisible balance, we have four different figures which can give rise to great confusion unless their scope is thoroughly appreciated:

(*a*) In Table 1 the "net shipping income" is shown as £85 million: this, as explained above, is the net shipping income including freights payable by British nationals to British nationals in respect of U.K. imports.

(*b*) If there is deducted from this £85 million the net payments to the U.K. in respect of foreign ships, namely £10 million, the resulting figure of £75 million represents the contribution to the invisible balance (calculated on the old basis), but is again inflated by the payments between British nationals.

(*c*) If we consider the shipping services account for 1936, in the form of Table 4, the balance is only £11·5 million, and this is the true net measure of the contribution of shipping to the exchange balance.

(*d*) This figure, however, does not measure the earnings of British shipping, but is reduced by a net expenditure on foreign ships. The contribution of British shipping to the exchange balance is given in Table 5 and is £24 million.

The following Table 6 gives a reconciliation between the "net shipping services of Table 1" and the net earnings of British shipping shown in Table 5. It will be observed that of the total of £85 million shown as net shipping services, £51 million is freight on U.K. imports earned by U.K. vessels:

TABLE 6

Reconciliation of Balance shown in Table 5 *with "Net Shipping Services" of Table* 1

	£ *million*		£ *million*
Estimated net shipping services (rounded up in Table 1 to £85 million)	84·8	Balance (Table 5)	24·0
		Net expenditure of foreign vessels in British ports less passenger fares by U.K. nationals in foreign ships	10·0
		Freight on U.K. imports earned by U.K. vessels	50·8
	84·8		84·8

Which of these figures is employed in any particular case depends on the context. At the present time the interest of the Government is centred very much on earnings of the foreign exchange, and from this point of view the contribution of the U.K. fleet was (in 1936) £24 million. If we are considering the surplus of exchange available after we have paid for the services of foreign ships, the appropriate figure is (on the 1936 basis) £11·5 million. Neither of these figures, of course, fairly measures the importance of shipping to this country, or the importance of British shipping in our international trade. They do, however, represent one important aspect of the exchange position.

There is a further complication which, from the Government's point of view, might necessitate the preparation of additional accounts. In 1936 international currencies were, with one or two exceptions, interchangeable, but under present conditions few currencies are free and Exchange Control recognizes various degrees of hardness or softness in the currencies of different countries, ranging from hard American dollars to soft French francs. The Government therefore might well wish to split some of the above figures if they related to current conditions into hard or soft currency accounts.

The question of greatest interest at the present time is whether it is possible to reconstruct figures in the form of Tables 4 and 5 for 1946 or 1947. I have given some consideration to this problem, but have come to the conclusion that it is practically impossible to make any reasonable

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estimates. If the present pattern of trade were at all comparable with that of 1936 we might have some success, but in fact it is not, and any estimates which could be put forward would scarcely be worth the paper they were written on. From the point of view of Exchange Control, the material factor is whether the balance of £11·5 millions shown for 1936 in Table 4 is positive or negative for the current year. I should guess that it is positive, and that it might lie between 10 and 20 millions; but this is little more than a guess based on a general "feel" of the position.

We can, however, make an estimate of the estimated net shipping income on the old basis comparable to the £75 millions of 1936 for British shipping. It appears that the appropriate figure for 1946 would be about twice as great, that is to say, £150 millions. This figure is derived from the known figures of present freight levels and tonnage imports, and it is confirmed very closely by some figures which have been published by the Norwegians on their own balance of payments.

I should expect that in 1947 and subsequent years the figure would be increased, say, to £175 millions or to £200 millions, as new vessels come into service, but this depends a great deal on the level of freights, which may fall considerably over the next five years, not so much because of declining costs of production as of an over-supply of tonnage.

I am unable to make similar estimates for the other items entering into the invisible export balance, but if we assume that the figure for 1947 is £300 millions, it follows from Dr. Snow's Table for case 1 in paragraph 10 that the index for all exports would have to be 170 and for class III exports 200. I must say that I share the general feeling that this is an impossible target unless there is a very material alteration in our present economic organization.

Mr. WILLSMORE said he had a little trepidation in speaking, but he had been told that statistics were common sense done with arithmetic. He had been baffled with figures so far, but had seen very little common sense. He was told that certain fantastic figures were our imports in 1936/38, or in 1938. He had a feeling that in fact there was such a thing as a trade cycle before the war, and that 1937 was a peak figure. Whilst he knew there were those who paid lip service to full employment and assumed we should continue in this country with an activity at least as high as that ever reached at the peak point of a business cycle, he did not believe that the plans were in fact being based on such a situation. It seemed therefore that it would be more realistic to recognize that the figures immediately pre-war were peak figures, and to consider the matter on what he believed was the right thing, the full sweep of the cycle.

However, what disturbed him even more was that implied threats were thrown out about the disparity between import and export prices, and how, in the event of a fall, export figures would not fall as much as imports. Nobody seemed to argue that when we said we should not live for ever in a seller's market that also meant that the people from whom we were buying would equally no longer live in a seller's market, and that we should not have to find this fantastic figure of sixteen and he did not know how many noughts to balance our imports and exports. He thought we should look through the binoculars the other way round.

The whole argument seemed to be based on some sum that was going to come into the country and what we had to send out to balance it on paper. Surely the situation in fact before the war was that it was the other people who were in those circumstances. We had due to us certain credits in respect of the goods we had exported, and further claims for materials, services and so on in respect of interest on loans, and all the other things that made the invisible exports. In those circumstances a number of things had come into this country because the other people had to send them in, not because we needed them. Surely we should now look at the thing objectively. We wanted, not a statistical basis for exports, but a common-sense basis for imports. We saw to-day much the same sort of thing that happened before the war. Many countries with obligations to us to-day were sending us melons at thirty shillings each and pineapples at fifteen shillings each, etc.

It had been said that we could not get timber. The timber that was coming into this country was about a third of the pre-war amount. But while it was true that we could not get timber, where before the war the furniture industry of this country could not export furniture, we were to-day importing furniture from Poland, Czechoslovakia, Holland, Canada, and would shortly do so from a number of other countries.

Should we not expect somebody to work out first of all the raw materials that we needed to import into this country to sustain a policy of full employment? That programme of full employment would equally cover employment on agriculture, which one must presume would produce an increased amount of food compared with pre-war years. There would, however, be left a required import of food to finance this full employment programme. If, when that was done,

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there was room for the import of what he regarded as luxuries—manufactured goods from abroad—we should then see how much of these we could afford.

Mr. COHEN said that Dr. Snow had himself regarded the analysis as a "somewhat academic statistical exercise," and he wondered whether the paper did not bring out the need for a much deeper analysis than Dr. Snow had provided. In the first place Dr. Snow had made assumptions as to the price level for exports and imports *in toto*, whereas it seemed to him that it would be more realistic to take the estimates of the price levels of groups I, II and III separately, and especially was it necessary for further analysis of exports when particular items such as, he thought Dr. Snow had mentioned, vehicles and machinery, played a very large part in group III; it might be necessary to subdivide group III further, and see what was likely to happen with regard to the prices and quantities of these commodities in particular.

The next point was that he thought they had lost sight of the immediate crisis and its effect on our economy. After all, the fuel possibilities must set limits to certain industries, and it was no good planning to export commodities that would require more fuel than could in fact be provided.

Further, he wondered whether it was right to take the level in exports of food and raw material as a percentage of the whole, and not to see what we were likely to produce and what were likely to be the limits to necessary home consumption.

An additional point to which he thought much attention had been directed recently was the need to examine the destination of our exports: we must, in fact, export to hard currency countries and export the things they needed, and if we realized that very shortly the sterling balances of many countries in Europe were going to be controlled, it would be no use at all our exporting to countries to which we were simply being paid from their sterling balances, and also we must consider what might happen if these countries were to refuse to hold some of their sterling in London, and if arrangements were made with these countries to that effect, the capital exported would have to be added to the deficits to be met, because if they found it more desirable to hold their balances in New York, where they stood more chance of getting goods, than in London, that would amount to an import surplus: in other words a loss of foreign exchange to this country which might be very serious.

Another point was the fact that while it was true our resources were running out, it was true also that the dollar resources of various European countries were running out much faster. If, for instance, the United States did not make further loans, those countries might be forced to buy from us, whether or not our prices were in fact competitive with those of the United States. Also it had been pointed out that they must bear in mind the possibilities of a United States slump, and whether the price of food which the United States exported might not fall considerably faster than the prices of manufactured goods.

The gist of it all, as it seemed to him, was that they were still trying to look at the export problem rather in a vacuum, and that exports had to be seen firstly in relation to our total national economy. As had been pointed out, it would be no use exporting coal if the British industry had to go without coal and reduce production. It was no good our exporting coal-making machinery, or large amounts of machinery vitally necessary for our own industry. Such exports must be seen, also, in relation to the world economy as a whole, not only to what we could produce, but to what other countries needed: it was no good saying we could expand exports of this or that if other countries were not likely to require them—especially we must satisfy the demands of the hard currency countries.

Then it seemed to him that exports had to be seen—and this was the most important point of all—in relation to our own requirements. Not only was it no good our exporting something from this country and setting an export target if we needed the product at home. If, for instance, we import tobacco, we had to make the choice between more imported tobacco and the goods we should have to export: we had to ask ourselves quite clearly in terms of the raw materials what were the things we should have to go without in order to have that tobacco, and which we would prefer.

We had always to bear in mind the whole problem of prices. So many people talked about the need to reduce our prices, ignoring the fact that in the last resource in exports it was values and not volume that really counted. If we reduced our prices we might, in fact, lose doubly: we might not only receive less imports, but we might also use up a greater amount of labour to obtain them.

Dr. SNOW in reply, said that apart from thanking Mr. Glenday and Mr. Kendall for their kind remarks he thought there was little more to say. There were some points in shipping

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accountancy which he found mystifying, but he hoped that they would be cleared up when he had had an opportunity of studying carefully Mr. Kendall's typically thorough statement on the matter.

As a result of the ballot taken during the Meeting, the candidates named below were elected Fellows of the Society:—

William Cecil Armstrong, A.C.I.S.
Alan Herbert Carter.
Charles Walter Emery.
Felix Fereday, M.Sc.
Roland Hughes, B.Sc.(Econ.).
Eileen Audrey Hunt, B.Sc.
John Harold Jenkins, B.Com., A.C.I.S.
Brendan Kevin Kelly, B.A.
Arthur William Lansley, A.I.M.T.A.
Emlyn Howard Lloyd, B.Sc., A.R.C.S., Ph.D.
Eynor Lloyd, M.A.
M. G. Neurdenburg, M.D., D.P.H.
Douglas Archibald Porteous, F.F.A.
Edward Austin Gossage Robinson, M.A.
Michael Robert Sampford, B.Sc., A.R.C.S.
Charles Patten Scarborough, B.Sc.
Valerian Sleptzow.
Kenneth Smith, B.Com., M.Sc.(Econ.).

Corporate Representatives

Sir Edmund Craster, *representing* All Souls College, Oxford.
Ian Thomas Morrow, *representing* Robson, Morrow and Co.

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A Statistical and Economic Survey of Certain Aspects of the Beef Producing, Milk Producing and Cattle Rearing Industries in Great Britain between 1939 and 1945

By Joan G. Marley

[Read before the Royal Statistical Society, April 24th, 1947, Dr. David Heron in the Chair]

Introduction

The object of this enquiry is to describe in quantitative terms certain changes that have taken place during the war in three of the live-stock industries in Great Britain, and to examine the extent to which their output, production methods and capital structure have been modified by wartime policy. The industries to be studied are those concerned with the production of fat stock for beef, with the production of milk, and with the rearing of young cattle. In addition the paper endeavours to show how the biological factors, which distinguish these industries from those in the manufacturing group, require a new approach to the problems of their economic and statistical analysis, an approach which necessitates as a first stage a detailed analysis of the cattle population.

Research into these industries has made little progress in the past because the data available before 1940 relate only to the number of cattle on farms. Since, as will be shown later, the functional relationship between total population and output is neither simple nor constant, these figures alone are of very limited value. After January, 1940, records of fat cattle slaughtered are available, but these new data have served only to emphasize the difficulties of using total population figures by themselves to explain changes in output. For instance, it has been found that an expanding beef population does not necessarily lead to increased beef production—in fact in recent years the reverse has been true.

If the data necessary for planning future policy are to be made available, further research is clearly essential. Without knowledge of the amount of investment in young stock, the length of the production process and the age composition of the capital units employed during the period of control, it is impossible to make plans for the future with any confidence. As already explained, the statistical data collected are fairly extensive, but they cannot explain why changes in output have taken place, nor describe any changes in structure or production practice which have been occasioned by wartime influences. The problem therefore with which this enquiry is concerned is to find a method by which the available statistics can be made to provide information regarding the extent of these changes. The statistics which are collected relate principally to numbers of cattle and to deaths from slaughter. This combination suggests the use of population technique, and a method is devised by which a series of statistics, parallel to vital statistics, is worked out for each group of cattle. By this means estimates are made of the inflow to each group and of the age composition of the group.

But this population analysis in itself cannot explain the output changes. There is, however, one feature of these industries which gives the population analysis a much wider significance: all the stages in the production of beef, milk or young stock correspond to a specific period in the natural cycle of growth and reproduction. This means that there is always a definite link between production policy and the composition of the cattle population, a change in one bringing an immediate change in the other. It follows, therefore, that given certain necessary adjustments in coverage and definition, the results of this population analysis can be used to investigate the industrial phenomena. One example will help to make this clear. A dairy heifer enters the herd on the day it calves for the first time. The vital statistics record the fact of a birth and the heifer is re-classified as a "heifer-in-milk." But looked at from the industrial viewpoint, the heifer becomes at that same date a milk producer and a new capital unit within the dairy industry. It follows therefore that if an estimate of the inflow of young stock and of the age composition of the population can be obtained for the war period, then these measures may be translated into economic terms and used in an analysis of industrial activity.

For this reason the first part of this enquiry is devoted to an analysis of the populations of each class of cattle, showing the change in size and age composition over the war years. Statistical

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series are worked out showing the rate of inflow of young stock, and the time spent in the herds either as breeding animals or as fattening stores. Wastage from deaths and slaughter is similarly analysed.

In the second part of the enquiry these statistics are related to the appropriate industry and the changes interpreted in the light of economic factors.

PART I—CHANGES IN THE CATTLE POPULATION BETWEEN 1939 AND 1945

SECTION I—DEFINITIONS, DATA AND METHODS

(1) *The main classes of cattle on farms*

Cattle may be classified biologically or according to function: thus male cattle are classed as bulls, steers or bull calves, and the females as cows, heifers or heifer calves. Alternatively mature cattle may be placed in one of three categories—beef producing, milk producing or breeding. In practice the functional classification is not very easy to apply, for farmers may move cattle from one group to another, such movements depending on breeding policy and on market conditions. For instance a store heifer may be transferred to breeding or a beef cow may be acquired for dairy purposes. In the statistical analysis that follows, mature cattle have been classified according to function, and the younger or "replacement" animals according to sex and age. The age groups associated with each class are of necessity rather arbitrary, as the dividing lines vary with different breeds and conditions of rearing. Thus while the class divisions may not be appropriate in particular circumstances, it is reasonable to suppose that they provide a sufficiently precise average for the population taken as a whole.

(a) *Meat producing animals or beef stores*

The beef store may be defined as a mature or fully-grown animal which is about to be or is being fattened for slaughter. Such animals may be fattened or "fed" on the farm on which they are born and reared, or on farms which purchase store cattle and prepare them for sale as fat cattle. Store animals may be either male or female—the male animals being known as steers or bullocks, and female animals as heifers. A beef animal is classed as a store when it reaches the age of about 24 months.* Some breeds mature earlier and some later, but this is agreed to be a workable average

Store cattle on farms in Great Britain fall into two categories—the home-bred and the imported. The home-bred steers and heifers are those born and reared on farms in Great Britain and Northern Ireland. The imported stores are brought from Eire at the age of two years or thereabouts and are fattened in Great Britain. These Eire stores are often of a heavier and hardier breed than the British counterpart, arriving on the farms in a more forward condition. As a result they tend to fatten at a different rate with a heavier carcase weight at slaughter.

(b) *Milk producing animals*

The milk producing or dairy class consists of heifers and cows which are regularly giving milk in excess of that required for their own or other calves.

The dairy animal is usually referred to as a heifer until the birth of the second calf. If it proves unsuitable as a dairy animal and is slaughtered after its first lactation, it will class as a "cow-heifer" as distinct from the beef heifers. Cows resting between the end of one lactation and the birth of the new calf are known as "dry cows." As the lactation lasts about 10½ months and the resting period from 6 to 8 weeks, the cycle of calving and lactation is roughly 13 months.

(c) *Breeding animals*

The two classes of animals within this group are the bulls kept for breeding and the cows maintained for calf-rearing and not for milk production.

The bulls may be attached to beef or to dairy herds, or if "dual purpose" animals may be used in either. The cow which is kept primarily for breeding will be found either in the specialist

* See Watson and More, *The Science and Practice of British Farming*, p. 521.

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beef herds (such as the Aberdeen Angus) or on farms engaged in the rearing of young dairy or beef stock for sale to other farms.

(d) *Replacement animals*

(a) *Calves*—This class consists of all male and female cattle under the age of twelve months.

(b) *Yearlings*—Cattle which have reached the age of one year and are under two years are known as yearlings. They include all male beef cattle (excluding bulls being reared for breeding) and all maiden heifers.

(c) *Heifers in calf with first calf*—Female cattle required for breeding or milk production are mated about the age of 21 months.* Until calving about nine months later they remain in the "heifers-in-calf" class. After calving these heifers will become part either of the dairy herds or of the herds kept for the breeding of young stock.

(2) *The data available*

The statistics available are of two kinds, those relating to the numbers of cattle on farms and those relating to the numbers imported or slaughtered. Information of the first type is obtained from the agricultural returns, whilst the other statistics are the by-product of the work either of the customs authorities or of other government departments in administering controls.

A. *The census of livestock*

Soon after the outbreak of the war the census was put on to a quarterly basis, with returns obtained for March and September as well as for June and December. The first Spring census was taken on March 4, 1940. At the following census, June, 1940, another vitally important change was made; in the class of "other cattle two years and over" and "one year and under two" the male and female animals were returned separately.

At a particular date, normally the 4th, in March, June, September and December of each year is known the number of all cattle on farms in Great Britain in the following classes:

Cows and heifers in milk
Cows in calf but not in milk (dry cows)
Heifers in calf with their first calf
Bulls for breeding
Other cattle—two years old and over, male and female
Other cattle one year and under two—male and female
Other cattle under one year—(*a*) Male, for service
(*b*) Male, for slaughter
(*c*) Female

B. *Statistics of imports*

To meet the requirements of the Ministry of Agriculture and Fisheries and the Ministry of Food, statistics are provided of landings of cattle at ports in England and Wales and Scotland, but excluding Northern Ireland. These figures include shipments of cattle between Northern Ireland ports and Great Britain ports—a movement necessarily ignored by the United Kingdom accounts. The following classes of cattle are distinguished:

Store cattle (male and female together)
Store dry cows
Milch cows
Springers (heifers in calf)
Store bulls
Calves

* See Watson and More, p. 495.

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Unfortunately no attempt is made to separate male and female store cattle, but as this is essential for the enquiry another source of information has to be found. The export statistics provided by the Ministry of Agriculture of Northern Ireland provide the data on which an estimate of the numbers of each sex can be based.

The Great Britain statistics distinguish between imports from Northern Ireland ports and imports from Eire ports. There is, however, a large movement of Eire cattle through the Northern Ireland ports of Belfast and Londonderry, and the use of the statistics of shipments from Eire ports alone results in a considerable understatement of their store exports to this country. Once again monthly figures of exports collected by the Northern Ireland Ministry of Agriculture allow the necessary correction to be made. Care must be taken in using these statistics of exports, because they are based on shipping cargo lists and the classification is thus the one adopted by the shipping companies—and different from that used by the agricultural authorities.

c. *Statistics of slaughtering*

All cattle purchased for slaughter by the Ministry of Food have been recorded since January, 1940. The figures are on a weekly basis, but it is convenient to use a statistical month of four and five weeks—the five-week month falling as the first in each quarter.

Three main classes of animals are distinguished: (*a*) cattle imported fat and ready for immediate slaughter, (*b*) cattle imported as stores from Eire, and (*c*) home-bred cattle.

Within each of these groups the steers, heifers and cow-heifers are shown separately. Details are also given of the number of fat cows and bulls slaughtered and of the number of casualties. The "casualty" is an animal which is slaughtered, often after an accident, before the official twelve days' notice has been given to the Ministry of Food. The casualty class also includes animals whose condition is such that the Ministry's graders will not grade on a live-weight basis. Cattle imported from Northern Ireland as stores are included with the home-bred cattle.

d. *Statistics of cattle hides purchased*

Figures of the number of hides purchased have been collected since the beginning of 1941 They show the number purchased from the Ministry of Food, and also the number privately acquired. The former agree very well with the statistics of cattle purchased by the Ministry of Food. The second category, those privately acquired, represent the animals which have died naturally or from illness. The two sets of figures taken together represent roughly the total disappearance of animals from the Great Britain herds. Unfortunately in these statistics no distinction is made between steers, heifers and cows, and the numbers of each have to be estimated. The information is collected on a weekly basis and the four- and five-week months are used.

(3) *The statistical methods used*

If the population is known at the beginning and at the end of a period, and the intake during the period is also known, then the outflow can be deduced. This is a method common to studies of vital statistics, and is equally applicable whichever of the four quantities is unknown. If, for instance, the population of a country is determined at a census and the births and deaths are recorded, then, provided there has been no migration, the population at the end of any subsequent period can be calculated.

A census of cattle is taken at quarterly intervals, giving separate totals for the beef and the milk and breeding populations. Since losses from slaughter and death are known the inflow to both classes can be deduced. However, for this enquiry it is not sufficient simply to know the total numbers in each group—an age distribution is essential. The census does not provide any information relating to the age of beef stores and dairy cattle, but data from other sources allow an estimate to be made. From such an age distribution the age at slaughter and the time spent in the herd can readily be ascertained. The method of obtaining the age distribution for each census and the use to which it can be put are described in the following paragraphs.

a. *Calculation of inflow*

The quarterly census records the number of cattle in all the classes distinguished, but as the outflow can only be ascertained for two of these classes—beef stores and cows and heifers in milk—

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the calculation must start at this point. The number of new entrants can then be obtained by using the population and outflow data. In the next stage of the calculation the estimated inflow to these two classes is taken as the outflow from the yearling classes. In the paragraphs that follow the case of beef cattle is described, but the methods are, of course, equally applicable to the milk herd.

The beef cattle sent for slaughter are drawn from the store-cattle class (returned in the census under the heading "steers and heifers two years old and over"), but further losses are due to natural deaths, and the total outflow from the class must be estimated. The formula then becomes:

Inflow to store class = change in population + numbers lost through slaughter and death.

B. *Age distribution*

A series of figures representing the inflow to the beef class between each census date can be thus obtained for the period December 1939, to December 1945. From this series an age distribution can be built up, showing the animals in each three-monthly age group. In order to do this advantage has been taken of a factor peculiar to the beef cattle population, that is that animals removed from the herds for slaughter are taken almost exclusively from the highest age groups. Natural deaths are so small compared with the number slaughtered that they can be neglected in constructing an age distribution.

It is assumed, therefore, that in any one period the oldest animals are the ones selected for slaughter and the ones most likely to die from natural causes.

Cattle enter the beef store class as they reach the age of 24 months, and at the quarterly census following their entry they can be placed in the age group 24–26 months. If it is assumed that there are no losses due to accident or similar causes, at the following census all these animals will be three months older and thus in the 27–29 months age group, the later entrants occupying the 24–26 months age group. In time, sufficient age groups will be tabulated to account for the total number recorded at the census date.

TABLE 1—*Specimen working sheet*

(Home-reared steers—thousands)

	Dec., 1941–Feb. 1942		March–May 1942		June–August 1942		Sept.–Nov. 1942		Dec. 1942
	At census date.	Change.	At census date.	Change.	At census date.	Change.	At census date.	Change.	At census date.
New entrants		95		147		94		84	
24–26 months	107		95		147		94		84
27–29 ,,	128		107		95		147		94
30–32 ,,	141		128		107		95	95–19	147
33–35 ,,	90	90–68	141	141–141	128	128–121	107	107–107	76
36–38 ,,	..		22	22–22	..		7	7–7	..
39–41 ,,	..		..		..		..		..
42 and over	..		..		..		..		..
Census total	466		493		477		450		401
Disappearance		68		163		121		133	

The technique is illustrated in the table above. Census totals are shown for five successive dates, December 1941, to December 1942. The estimated disappearance from the herd is shown at the bottom of the table for the three-monthly periods–December 1941–February 1942; March–May 1942; June–August 1942; and September–November 1942 (all inclusive). The figures of new entrants shown on the top line are calculated as described above. In this example between December 1941, and February 1942, 95,000 animals enter the store class and at the March census are placed in the 24–26 months age group. At June they are all between 27–29 months, and at September 1942, between 30–32 months. Similarly the 147,000 entering in the period March–May 1942, and the 94,000 entering June-August have been placed in the younger age groups.

In the table each inter-census period is given two columns, one for the distribution by age at the census and the second showing the change which takes place in the following three months. To take the period September to November 1942, as an example, the new entrants number 84,000, and 133,000 are removed on account of slaughter and deaths. As it is assumed that the oldest

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animals are withdrawn first, this 133,000 is made up of the 7,000 in the 36–38 months group, the 107,000 in the 33–35 months group, together with 19,000 of the 30–32 months group. The 76,000 animals remaining from the 30–32 months age group will therefore appear at the December census.

The number of new entrants thus establishes the size of the three lower age groups, but it is changes in the number slaughtered which affect the numbers in the higher age groups. When, for instance, fewer animals are sent for slaughter than appear in the oldest age group, the remainder which are not slaughtered enter a still higher age group. Such an occurrence may be purely seasonal, or it may be part of a definite trend. The table emphasizes a simple arithmetical relation that if losses to the herd are allowed to fall below the number of new entrants over a short period, not only will the numbers in the population increase, but the length of time spent in the herd by the older animals will also increase.

Such a calculation can only purport to give a general picture of the situation. It is perfectly clear that at, say, December 1941, some beef animals are older than 36 months. If it is 5,000, then this figure must be deducted from one or two of the other age groups. It might be more logical to split the disappearance figure to give such a result, but as there is no direct evidence the straightforward method seems preferable. The possibility of there being a few animals of ages greater than are shown here must, however, always be kept in mind in interpreting the results.

c. *Length of time spent in the herd and the average age at slaughter*

This method allows two further measurements to be made: the length of time spent in the herd by any particular group of animals, and the average age at slaughter of animals marketed in any one period of three months.

The table shows the method. In the months December 1941, to February 1942, 95,000 animals enter the store class. For six months this group remain intact, but between September and November 1942, 19,000 of them are sent for slaughter, leaving 76,000 to be recorded at the December census. It can therefore be shown that these 95,000 animals entering in the Winter of 1941–42 are slaughtered in the Winter of 1942–43—they spend between 9 and 12 months in the store class.

Secondly, to determine the average age at slaughter it is assumed that each animal is killed as it reaches the limit of the relevant age groups. In the period September–November 1942, for instance, the 7,000 oldest animals are slaughtered as they reach the age of 39 months, the 107,000 in the next oldest when they reach the age of 36 months, and so on. The average age at slaughter in that period is therefore:

$$\frac{(39 \times 7) + (36 \times 107) + (33 \times 19)}{133} = 35{\cdot}7 \text{ months}$$

Such figures are of much greater significance when worked over a period of time. The figures are available from December 1940, to December 1945.

This method assumes an even spread within each three-monthly age group. Inspection of the inflow figures, which show marked seasonal fluctuations, suggest that this is unlikely and may lead to error in the results. For this reason, in the sections that follow, all calculations of the age at slaughter have been done on a monthly and not on a quarterly basis. Inter-census values have been obtained by smoothing the population curve.

SECTION II.—THE BEEF POPULATION

The beef store population in Great Britain is made up of two classes of animals—steers and heifers born on farms in Great Britain and Northern Ireland and steers and heifers imported from Eire. Since this investigation is confined to animals in Great Britain, the Northern Irish stores need a note of explanation. Although they are imported in the same way as Eire stores, they resemble very closely the home-reared animals, and the Ministry of Food does not distinguish them in its records of numbers slaughtered. In this enquiry it is intended to follow the same practice, partly for convenience, and partly because the numbers involved are too small to make any significant difference.

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The Eire stores, on the other hand, are known to be of a heavier and hardier breed with early maturing and fattening qualities. It is therefore essential to study this group of animals separately. Although farmers are not asked to distinguish Eire stores in their quarterly census schedules, it has proved possible to estimate their numbers with the aid of data provided by the Ministry of Food and the Agricultural Departments. Thus, with the number of Eire stores established at each census, the number of home-bred cattle can be obtained by difference.

In this calculation it is assumed that the practice of "baby beef" and "young beef" production is discontinued in the war years. A "baby beef" is marketed at 15 to 18 months, which means missing the store period. In the two following sections the statistical methods used are described, and changes in the population of the imported and home-bred cattle are examined. The third section discusses the part played by both classes of cattle during the war years.

(1) *Stores imported from Eire*

(*a*) *The number entering Great Britain*

For as long as records have been kept the entry of Eire stores into Great Britain for fattening has been a regular feature of the livestock industry. It is not therefore a movement peculiar to the war years. The following table shows the annual figures of imports between 1934 and 1945. For convenience of transport a large number of Eire stores are shipped through the ports of Belfast and Londonderry, and for this reason the figures given below exceed those quoted by the Ministry of Agriculture as "shipped from Eire ports." There are, in fact, more Eire stores than Northern Irish stores passing through Northern Ireland ports.

TABLE 2—*Estimated imports of Eire stores into Great Britain in* 1934–1945 (*thousands*)

Calendar year	Total	From Eire ports	From Northern Ireland ports
1934	286	220	66
1935	420	330	90
1936	479	414	65
1937	485	414	71
1938	435	353	82
1939	531	425	106
1940	430	326	104
1941	65	34	31
1942	374	271	103
1943	336	245	91
1944	305	211	94
1945	331	263	68

Before June 1939, the Ministry of Agriculture did not keep separate records of imports from Eire ports, but only for Ireland as a whole. The Ministry of Agriculture of Northern Ireland, however, has complete records of shipments from Northern Ireland ports in the pre-war years. The figures prior to 1939 in the above table are obtained with the aid of these statistics. The table shows that imports of stores from Eire are on the average about 30 per cent. lower than before the war. The highest figure, 531,000, is recorded in 1939.

A detailed study of the number of store cattle imported from Eire cannot be undertaken with the aid of Ministry of Agriculture figures alone for two reasons; the coverage is incomplete, and male and female animals are not recorded separately. These figures are nevertheless used as a base throughout the calculation.

As a first step the coverage must be expanded so that all animals originating in Eire are included. To the import records must be added the Eire stores shipped direct to ports in England and Wales and Scotland, but using the Northern Ireland ports. The statistics provided by the Ministry of Agriculture of Northern Ireland relate to exports from that country. It is not entirely satisfactory to add import figures to export figures, but as the channel crossing takes only a few hours no correction has been attempted. The complete series of figures for the war years is shown below in Table 3.

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TABLE 3—*Imports of store cattle from Eire (thousands)*

	1940	1941	1942	1943	1944	1945
Total	446	59	368	347	305	333
December–February	103	30	71	71	61	49
March–May	126	—	81	62	62	74
June–August	83	—	79	80	58	75
September–November	134	29	137	134	124	135

The figures show that a minimum number of 12,000 store cattle a month are taken by Great Britain farmers, whilst in some months the number may be as great as 60,000. There is, moreover, a very marked seasonal movement in these imports—the largest number always arriving in the months of October and November. This suggests that Eire stores are used more for Winter fattening in stalls than for Summer feeding. There is, nevertheless, for heifers a secondary peak occurring in March and April, and this must represent animals bought for fattening on the grass during the Summer months in 1940 in the year of import, in later years after a Winter held as stores.

(b) *The number slaughtered in Great Britain*

The number of imported stores purchased for slaughter by the Ministry of Food has been recorded since January 1940. Steers and heifers are always shown separately. In the table below the totals are shown for the periods between the December censuses.

TABLE 4—*Number of imported stores slaughtered (thousands)*

	Total	Steers	Heifers
1940	444	290	154
1941	257	186	71
1942	166	121	45
1943	271	216	55
1944	290	237	53
1945	290	243	47

The most striking thing is the decrease in the numbers slaughtered: 444,000 in 1940 compared with 290,000 in 1945. The low figure for 1942 is, of course, explained by the cessation of imports in the eight months of the previous year due to an outbreak of foot-and-mouth disease.

The table also brings out the relative importance of steers and heifers. Although the number of steers slaughtered has always been larger than the number of heifers, this predominance has increased throughout the war. Heifer slaughterings are 35 per cent. of the total in 1940, compared with 16 per cent. in 1945. Heifer slaughterings also recover very slowly from the abnormally low 1942 level. In 1944 they are only 8,000 higher, whereas slaughterings of steers have nearly doubled in the same period. By 1945 the numbers have fallen again to 47,000.

The seasonal variation in the numbers slaughtered is considerable and is illustrated by the quarterly figures given in Table 5 below. The largest number of steers come forward in the March–May quarter, whereas heifer slaughterings are concentrated in the period September to November.

(c) *Time spent on farms in Great Britain*

It is generally accepted that an imported store will spend six months on a Great Britain farm before being sent for slaughter. For the purpose of this investigation it is essential to test this hypothesis.

In 1941 there is a serious outbreak of foot-and-mouth disease in Ireland, with the result that no stores at all are imported to Great Britain from February to September inclusive. This cessation of imports causes an abnormal break in the statistical series, and this has been used to obtain the required information.

A graphical method has been found the most convenient. Cumulative totals of the imports and slaughterings of steers are plotted between December 1939, and December 1943. It is then seen that the inflow curve rises steadily until December 1940, when it flattens out, the value being

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TABLE 5—*Number of imported stores purchased for slaughter (thousands)*

		Total	Steers	Heifers
1940	December–February	106	75	31
	March–May	101	82	19
	June–August	94	56	38
	September–November	143	77	66
1941	December–February	84	59	25
	March–May	89	74	15
	June–August	53	36	17
	September–November	31	17	14
1942	December–February	14	9	5
	March–May	38	34	4
	June–August	51	39	12
	September–November	63	39	24
1943	December–February	34	25	9
	March–May	107	98	9
	June–August	87	69	18
	September–November	43	24	19
1944	December–February	38	30	8
	March–May	114	107	7
	June–August	84	67	17
	September–November	54	33	21
1945	December–February	35	30	5
	March–May	101	96	5
	June–August	88	72	16
	September–November	66	45	21

about 310,000. When the "slaughter" curve is examined in the same way the flattening occurs when the cumulative total reaches 440,000, that is, in June 1941. The figures confirm that from that date slaughterings are well below the level of the previous year. The second flattening in the curve thus occurs six months after the first, and this suggests that the time spent by stores in this country at the beginning of the war is about six months; that is, despite the cessation of imports at the beginning of 1941, slaughterings are not affected until June 1941.

When similar curves are plotted for heifers, the results obtained are very similar. If anything, the period is nearer seven months. A further check may, however, be obtained by inspection of the import and slaughter data. A group of animals arriving in any one month can be traced in the age-distribution until they are sent for slaughter. Steers, for instance, give the following results:

Steers imported in—		Number of months spent in herd before slaughter
1939	December	6+
1940	January	7
	February	7
	March	6+
	April	6
	May	6
	June	6+
	July	6
	August	6—
	September	6—
	October	6—
	November	6+

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It can therefore be concluded that the assumption of a six months' stay in Great Britain is correct for the first twelve months covered by this enquiry.

(d) *Changes in numbers of Eire stores in Great Britain*

The estimation of the number of Eire stores in the country sets a very interesting statistical problem. The methods described on page 190 are not directly applicable because the data are insufficient; the records of imports and slaughterings provide only two of the four unknowns.

The difficulty is overcome in two stages, the first being to estimate the stock at the opening date, December 1939, and the second to determine the distribution by age at the same date.

The available data have already been described. It consists of (*a*) the estimated number of steers and heifers imported, and (*b*) the number of steers and heifers slaughtered. From these figures another quantity can be deduced—the *change* in population in each quarter. This is extremely important, for it means that only one population figure has to be obtained—the population figure at the opening date; the others can be obtained by adding or subtracting the known change. If, for instance, the heifer population at December 1939, is found to be X, the imports 34,000 and the slaughterings 31,000, then the population at March 1940, must be:

$$\begin{aligned} \text{March population} &= (X + 34{,}000 - 31{,}000) \\ &= X + 3{,}000 \end{aligned}$$

Similarly, the population at June 1940, will be:

$$\begin{aligned} \text{June population} &= (X + 3{,}000) + (66{,}000 - 19{,}000) \\ &= X + 50{,}000 \end{aligned}$$

The problem of estimating the population at December 1939, is solved by an examination of the cumulative figures relating to imports and slaughterings. The inflow and outflow of steers are in step until December 1940. After this date imports fall off and then stop altogether until October 1941, but slaughterings continue. This can only be explained by the presence of a stock of animals at the beginning of the period, and this stock can be measured quite simply as follows:

In the period December 1939 to September 1941 (inclusive), 466,000 animals are slaughtered, whereas the corresponding inflow figure is 313,000. Thus 153,000 animals (466,000 — 313,000 = 153,000) must come out of the stock on farms at the beginning of the period. However, during the following two months, October and November, a further 10,000 come forward for slaughter, and these have not been drawn from the resumed imports after October, 1941. These also must be in the original number. The population at December 1939, can therefore be estimated at about 163,000 (153,000 + 10,000 = 163,000).

This may also be shown graphically. The widest gap between the curves of inflow and outflow is 150,000. This would be the stock figure (*a*) if farmers have got rid of all Eire animals by that date and (*b*) have included 4,000 animals imported in the last month. A minimum of two months' stay can be assumed here; thus the 10,000 animals slaughtered in October and November must be included in the stock. That is 155,000 + 10,000 = 165,000. For the purpose of this investigation the stock has been estimated at 165,000 animals.

A similar calculation can be done for heifers. The minimum stock calculated at the end of October 1941, is (221,000 — 163,000 = 58,000), to which must be added 8,000 to account for additional slaughterings, from November to January 1942. The first of the new imports are slaughtered in February 1942. The stock has therefore been estimated at 66,000. The total number of imported store cattle in Great Britain at the December 1939, census is therefore taken to be 231,000.

The second stage, the determination of the distribution by age, is completed by using a result obtained previously—that is, the time taken to fatten a store animal was six months in the early months of the war. It should be noted, however, that owing to the uneven monthly inflow some animals do actually reach the age of 30 months or above before being slaughtered.

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With this information estimates are made on the lines described on page 190. The population of imported stores is shown at each census date in the following table:

TABLE 6—*Estimated number of imported stores on farms in Great Britain (thousands)*

		Total	Steers	Heifers
1939	December	231	165	66
1940	March	229	160	69
	June	254	138	116
	September	242	130	112
	December	233	164	69
1941	March	179	129	50
	June	90	55	35
	September	37	19	18
	December	35	28	7
1942	March	92	70	22
	June	135	83	52
	September	163	98	65
	December	237	174	63
1943	March	274	202	72
	June	219	140	79
	September	197	121	76
	December	275	208	67
1944	March	294	225	69
	June	239	161	78
	September	211	138	73
	December	277	213	64
1945	March	290	221	69
	June	263	170	93
	September	250	149	101
	December	319	217	102

The graph of population movements has some interesting features. In the first place there are two distinct periods divided roughly at the June 1942 census. Before that date there is a rise over the first few months followed by a sharp fall, whereas later the curve shows a clear seasonal pattern with a distinct upward trend. The reason for this difference can be explained quite simply. Imports in 1939 are the highest for many years, and although slaughterings keep pace to some extent, a rise in the numbers kept on farms results. After January 1941, no imports are allowed for eight months—a loss of something like 320,000 animals. The population falls until the December 1941, census, when it reaches its lowest point, but recovers rapidly in the next six months as imports are resumed. However, by March 1943, the population is above the level of March 1940.

The very abnormal imports in the period before June 1942, affect the population curve in another way—the masking of the seasonal pattern. This, however, quickly reasserts itself. The graph shows clearly that the total population is seasonally high at the March census, and then falls to its lowest level in September. The numbers in the winter are, moreover, considerably greater than in June.

One further point should be mentioned here. It can be estimated again by a graphical method, that of the heifers imported in 1943 and 1944, 52,000, or 37·4 per cent., are mated. This is a very high proportion, and is an interesting measure of the effort made by farmers to increase the country's milk production. It is interesting to note that despite the extensive diversion from the beef herds, the heifer population continues its recovery from the low level caused by the eight months' cessation of imports. This increase can only be achieved in one way—a reduction in the rate of slaughter.

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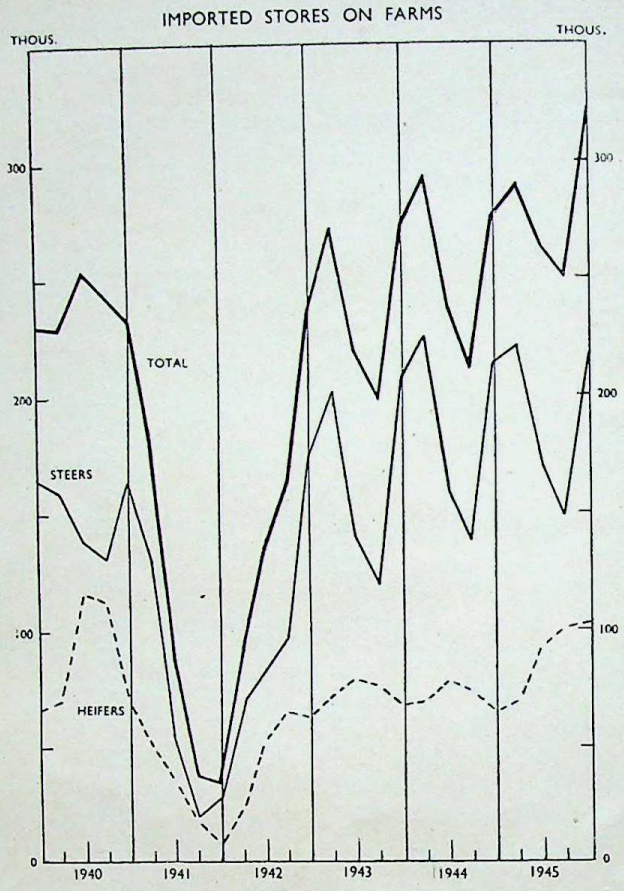

GRAPH 1

The fact that this is done over a long period is confirmed by the records of heifer slaughterings (Table 5).

(e) *Age at slaughter*

The method used to determine the age distribution of imported cattle in Great Britain is described in Section I, the figures being worked separately for steers and heifers. The average age of steers and heifers slaughtered in each month since December 1939, is then calculated, and the results are given for census months in Table 7 below—monthly data being used throughout.

The average age of steers and heifers at slaughter has been calculated for all months from December 1939, to December 1945, inclusive, but for the convenience of analysis the period is divided into three phases. The first period lasts until the cessation of Irish imports in February 1941, the second until the stock of Irish animals has been exhausted, and the third and longest phase from February 1942, when the rebuilding of the herds starts, until December 1945.

At the opening of the first period animals are slaughtered at 30 months or less—after the traditional "six months' period of keep"—but a rise is evident within the next few months. If the December and January figures are compared with those of the following year it is seen that the increase is between one and three months.

In the second phase from February 1941, no replacements are available, and farmers have only their stock of 152,000 steers and 57,000 heifers to draw upon. If slaughterings continue at the rate of the previous year this stock will be exhausted by about August, 1941, but the figures show that the available animals are marketed more slowly and the last do not come forward until

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TABLE 7—*Estimated average age at slaughter (months)*

Census months.		Total	Steers	Heifers
1939	December	29·0	29·5	28·0
1940	March	29·2	29·0	29·9
	June	30·8	30·4	31·8
	September	30·8	30·9	30·7
	December	30·3	30·5	31·0
1941	March	30·1	29·6	32·0
	June	31·5	31·0	34·0
	September	33·7	33·0	34·6
	December	35·5	35·0	36·0
1942	March	30·9	31·0	30·0
	June	32·4	32·5	32·0
	September	30·5	29·9	31·9
	December	31·4	31·0	32·0
1943	March	32·0	31·7	34·0
	June	32·1	31·5	36·0
	September	33·9	32·4	36·8
	December	36·0	34·0	38·0
1944	March	34·3	33·9	39·0
	June	33·2	32·0	41·0
	September	35·9	33·3	41·0
	December	36·2	35·0	41·0
1945	March	35·6	35·1	42·0
	June	33·5	33·0	43·5
	September	35·4	33·7	41·8
	December	36·3	34·0	40·5

TABLE 8—*Average age at slaughter (months)*

	December		January	
	1939	1940	1940	1941
Total	29·0	30·3	28·5	30·5
Steers	29·5	30·5	28·3	30·1
Heifers	28·0	31·0	28·9	31·4

January 1942. This decision to delay marketing results in an unavoidable increase in the age at slaughter—for instance the average age of steers in December 1941, is 35 months, compared with 30·5 months a year earlier. For heifers corresponding figures are 36 months and 31 months—thus the delay results in an increase of about five months in the age of slaughter.

The first of the new stock of imported stores come forward for slaughter in February 1942—the beginning of the final phase. This period necessarily opens with a low average age at slaughter, as at first animals tend to be marketed fairly quickly after arrival in this country. Allowing for the fact that only "forward stores" are allowed in the first two months of the resumed imports, the age at slaughter in February 1942, is estimated at 30 months. However, the rise in the age at slaughter described in the first period quickly reappears. After a correction has been made for seasonal variations it is estimated that the average age of steers in February 1945, is 13 per cent. higher than in February 1942; for heifers it is 44 per cent. higher.

Statistical analysis cannot give a complete explanation of these changes, but the figures suggest certain conclusions.

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In the first phase farmers have plenty of animals and feeding-stuffs are not rationed. Farmers nevertheless delay slaughterings and the average age rises. This suggests that greater economy is being exercised in the use of concentrated feeding-stuffs as the statistics relating to supplies do not show any actual scarcity.

In the second period the position is quite different. Farmers are faced with a shortage of stores, and they prefer to spread the marketing of this limited number over a much longer period. More precisely, in the absence of the usual Autumn imports for stall-feeding, about 20,000 grass-fed animals appear to be held over the Winter to dispose of straw and roughage.

In the final period more than one factor is certainly operating. By this time concentrated feeding-stuffs are definitely short and the amount of pasture is reduced. But an examination of the population figures does suggest that despite all the difficulties, farmers are determined to maintain the size of their beef herds. However, at this time beef stores are in short supply (due mainly to the demand for dairy stock) and this building up of the herds can only be achieved by a slower rate of slaughterer and a slower rate of slaughter means an increased age at slaughter. This suggests, therefore, that the rise in the age at slaughter over the last three years is due to two factors operating together—the shortage of concentrated feeding-stuffs required for quick finishing, and the desire to maintain herds of imported cattle in the face of inadequate replacements.

(2) *The home-bred store population*

(a) *Changes in the number of home-bred stores*

The total number of beef steers and heifers, both home-bred and imported, is recorded at each quarterly census. The home-bred stores cannot be distinguished from the census data, but it is clear that an estimate of their numbers is possible if the imported store population is known. This method has therefore been used. At each census the number of imported stores, as estimated in the previous section of this paper, has been deducted from the total recorded population. Separate estimates have been made for steers and heifers.

In Tables 9 to 11 below these estimates are shown for the period 1940–1945.

TABLE 9—*Estimated number of home-bred stores on farms (thousands)*

	1940	1941	1942	1943	1944	1945
March	900	922	924	843	915	996
June	960	966	950	873	950	1,048
September	970	984	923	899	1,006	1,037
December	888	944	859	905	1,018	1,038

In June 1940, it is estimated that there are 960,000 home-bred beef stores in Great Britain. However, the table shows that the numbers fall in the Autumn of 1940, but then rise steadily during the following Spring and Summer, so that in September 1941, the population numbers 984,000. After September 1941, the movement in population divides naturally into two phases: an almost unbroken decline until March 1943, followed by a steady rise lasting until June 1945. At December 1945, the population is estimated to be 150,000 higher than at the corresponding census five years earlier.

It is interesting to note that the rise in population after December 1940, is coincidental with the period of cessation of imports of stores. It is possible therefore that some home-bred cattle are retained longer than usual in order to minimize the inevitable drop in the number on the farms. When the Irish imports are again available the decline in the home-bred population is seen to be resumed.

Of the 960,000 home-bred cattle on farms in June 1940, 443,000, or 46 per cent., are steers. Over the five war years there has been practically no change in this figure; the 1945 June figure is 436,000. The population curve has a distinct seasonal pattern, with the peak in March and the trough in December. These seasonal movements are, however, interfered with in the year 1941, for the curve rises instead of falls between June and December. A reasonable assumption is that in this period home-bred animals are being retained on farms to take the place of Irish steers. In

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March 1942, the steer population reaches 493,000, the highest figure ever recorded. It is estimated that of this number about 65,000 animals are "over-age," and held on farms to maintain the quota of animals for Winter stall-feeding.

GRAPH 2

The figures of home-bred steers at each census date are shown below in Table 10.

TABLE 10—*Estimated number of home-bred steers on farms (thousands)*

	1940	1941	1942	1943	1944	1945
March	412	441	493	435	436	447
June	443	435	477	412	412	436
September	455	456	450	394	420	411
December	412	466	401	387	406	408

The heifer population is considerably larger than the steer population—at June 1940, the difference amounts to 74,000, and in June 1945, to 176,000. Only on two occasions does the number of steers exceed that of heifers, and this occurs at the March census in the years 1942 and 1943. Moreover, unlike the steer population the number of heifers on farms has shown a considerable increase during the war; the number in June 1945, is 95,000, or 18 per cent. above the number in June 1940.

This increase has not been continuous over the whole period. An increase in population is seen when no imports are permitted owing to foot-and-mouth disease, but immediately afterwards a sharp fall occurs, and the number recorded at the June 1942 census is 58,000 below the number twelve months before. It appears therefore that the size of the home-bred population is immediately affected by the heavy demand for dairy stock which occurs about this time. The population falls still lower in the following year, 1943, and at the March census is only 408,000; the lowest figure recorded since the data became available.

March 1943, is a significant date from two points of view. Not only does it mark the lowest point reached by the heifer population curve, but it divides the period of erratic movement from one of steady increase. For in the next two years the figures show a rising trend with a very distinct seasonal variation. As the figures in Table 11 show, the trough comes in March of each

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year, the numbers rising during the Summer and Autumn to make December the peak month. It is not possible to determine whether this particular seasonal pattern is true of the early months of the war because the conditions are then abnormal. However, the March trough is evident as early as 1942, and the graph suggests that a correspondingly low figure might have occurred in 1941 had it not been for the cessation of imports.

TABLE 11—*Estimated number of home-bred heifers on farms (thousands)*

	1940	1941	1942	1943	1944	1945
March	488	481	431	408	479	549
June	517	531	473	461	538	612
September	515	528	473	505	586	626
December	476	478	458	518	612	630

It is interesting to compare the seasonal variations of the steer and heifer populations: the movements are seen to be directly opposite. In March, when the steer population reaches its peak, the heifer population is at its lowest point. Thus the seasonal decrease in the numbers of steers between March and December of each year tends to offset the seasonal increase for heifers, and the graph of the total population emerges as a smooth rising curve.

(b) *Recruits to the beef herds*

In this section it is intended to study the flow of young (two-year-old) animals into the beef herds, and to examine the changes that have taken place since December 1939.

Recruits for the store class are drawn from two sources—the home-reared yearlings and imports from Northern Ireland. These two groups will be considered separately in the following paragraphs.

The total monthly inflow in the beef herds is deduced from the available data, using the method described in Section I. Of the four variables, three are known: the opening and closing populations and the number removed. The fourth, the inflow, can therefore be deduced.

(1) *Inflow from home-reared yearlings.*—The number of recruits coming forward from the steer yearling class is governed entirely by the decisions of breeders and rearers two years before. Taking the country as a whole, nothing but a wholesale slaughter of immature animals can alter the pattern. This inflexibility of the inflow pattern is a factor to be noted, since it is a characteristic peculiar to the male side of the inflow.

As the table below shows, the number of home-bred males passing into the store class has steadily decreased since 1941; the total for 1945 is 114,000 less than for 1940, and 147,000 less than for 1941, which has the highest inflow yet recorded.

TABLE 12—*Estimated number of home-reared steers passing into beef herds (thousands)*

	1940	1941	1942	1943	1944	1945
Total	484	517	408	398	399	370
December–February	119	142	93	100	102	92
March–May	162	140	144	131	121	111
June–August	108	129	91	99	109	78
September–November	95	106	80	68	67	89

The factors governing the rate of recruitment to the heifer population are much more complex, and not, as with steers, directly related to the number of calves reared. In examining the changes in the rate of inflow it is convenient to divide the population of yearling heifers into three categories: those reared specifically for breeding, those specifically as stores, and a third group capable of being used either for breeding or as stores. The proportion of this last group entering the beef herds in any period will depend on the demand condition reigning at that time. Further, under exceptional conditions the intermediate yearling class may not be sufficiently large to meet the demand from one side or the other and the specialist categories may be invaded. As Table 13

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below shows, there is definite evidence that the tremendous demand for milk stock from 1941 onwards makes heavy inroads into the class of animals intended as stores.

TABLE 13—*Estimated number of home-reared heifers passing into beef herds (thousands)*

	1940	1941	1942	1943	1944	1945
Total	379	370	272	323	401	380
December–February	105	92	9	—	12	—8
March–May	88	129	108	115	122	121
June–August	74	90	69	113	125	111
September–November	112	59	86	95	142	156

It should be noted that the above table has been computed on a net basis. It is known that the increase in dairy stock has partly been obtained by mating heifers older than two years—those already in the beef group as defined in this paper. The precise number of these diversions cannot be obtained, which means there is no way of estimating the total outflow from the beef heifer population, *i.e.* slaughter and deaths plus diversions. The difficulty has, however, been by-passed by finding the "net inflow" or, in other words, the "retained inflow." Should the diversions in any one period exceed the actual inflow from the yearling class, the difference measures the "net inflow" and appears in the table as a minus figure.

In the first year for which data are available, 1940, it is estimated that roughly 380,000 heifers enter the beef herds. The number entering is slightly lower in 1941, then falls sharply to 272,000 in 1942. The numbers rise in 1943 and 1944, but in 1945 fall back to the level of 1940.

In 1940 and 1941, despite considerable variation in the rate of inflow over the year, there is no apparent seasonal pattern, but from 1942 onwards the position is very different. The most striking change is the fall in the December to February inflow from around 100,000 to *nil*, whilst in 1945 the diversions exceed new recruits by 8,000. The inflow in the Spring months is affected little, if at all, and there is no very marked change in the June–August quarter. On the other hand, the Autumn inflow, which falls to 59,000 in 1941, has been rising steadily and reaches 156,000 in 1945—the highest figure reached for any period of three months.

It is quite clear that the drive for increased milk production has met with an immediate response from farmers, and furthermore, that the effect on the rate of inflow to beef herds is still being felt in the Winter quarter. In order to explain the heavy drain in this particular quarter, it must be remembered that a heifer is normally mated about the age of 21 months, and will be in calf for nine months after being served. Thus the missing heifers due for entry into the beef herds in December, for example, will probably have been mated in the previous September. These animals therefore will calve in June. Thus heifers diverted from beef in the December to February quarter will enter the milk herds as heifers-in-milk during June, July and August. Thus not only is there an immediate and substantial response to the appeal for increased milk production, but a genuine attempt to use the additional heifers for Winter milk production. For it is clear that the robbing of the beef herds of their recruits between December and February means an equivalent increase in the number of milking cows and heifers during the following Winter. Nevertheless, the total number of heifers entering the beef herds during 1945 equals the total for 1940, before such complications arise. Thus farmers are compensating themselves for the loss by obtaining a larger number in the other three quarters of the year, particularly in the Autumn quarter of 1944 and 1945.

When the two series of inflow figures are compared it is clear that the inflow of steers exceeds that of heifers for the years 1940–1943. In 1940, of the 863,000 new entrants, 484,000, or 56 per cent., are steers. Similarly steers form 60 per cent. of the home-bred inflow in 1942. However, in 1944 only 50 per cent. are steers, and in the following year the number of heifers entering the herd, 380,000, exceeds that of steers by 10,000. The comparison is set out in Table 14 below.

(2) *Imports from Northern Ireland.*—The number of imports from Northern Ireland is very small compared with the stores originating in Eire. In 1940 steer imports number 21,000 and heifer imports 32,000 compared with 289,000 steers and 157,000 heifers from Eire. The 1941

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TABLE 14—*Estimated inflow of home-reared yearlings (thousands)*

	Total	Steers	Heifers	Steers as per cent. of total
1940	863	484	379	56
1941	887	517	370	58
1942	680	408	272	60
1943	721	398	323	55
1944	800	399	401	50
1945	750	370	380	49

total is affected by the complete cessation of imports lasting eight months, due to an outbreak of foot-and-mouth disease.

It is believed that a number of these Northern Irish stores are below the age of two years at the time of import. The proportion suggested for the under-age cattle is 30 per cent., but as the numbers imported are so small and the estimate rather uncertain, no adjustment has been considered necessary.

The contribution made by Northern Irish imports to the home-bred store population is relatively small. As the table below shows, Northern Ireland never provides more than 6 per cent. of the total inflow.

TABLE 15—*Total inflow to home-bred beef population (thousands)*

	Total	Home-reared	From Northern Ireland	Per cent. from Northern Ireland
1940	916	863	53	5·8
1941	890	887	3	0·3
1942	708	680	28	4·0
1943	752	721	31	4·1
1944	823	800	23	2·8
1945	785	750	35	4·5

(c) *Home-bred stores leaving herds for slaughter*

(1) *Age of home-bred cattle at slaughter.*—The available statistics do not permit an estimate of the age at slaughter before June 1940. In that month the age of the cattle slaughtered averages 34 months for steers and nearly 39 months for heifers—a difference of almost five months.

By the following June the average age of steers has risen only slightly, but by June 1942, is two months above the opening figure. The corresponding estimate for June 1945, is 37 months—showing that on the average steers are slaughtered about three months older than at the beginning of the war. Impressed on this rising trend is a distinct seasonal variation, the average age in October and November (a period of heavy slaughterings) being considerably lower than at other times of the year.

On the other hand, animals with a higher average age at slaughter are generally marketed in March. A further feature worthy of notice is the increased age of the steers marketed immediately after October 1941. The rise in the next five months is considerably greater than that observed over the same period of 1940, with the result that the March 1942, average works out at 36·6 months. Thus half of the total increase observed between 1940 and 1945 occurs during this period. The averages for each census month are given in Table 16 below.

This moderate rise in the age of steers at slaughter contrasts sharply with the experience of heifers. In the first place the average age in June 1940, is 4½ months above that for steers. But in addition the increase over the three following years is much greater, and the average age in June 1943, is 44·7 months compared with 38·6 months in June 1940. After June 1943, there is no further rise in the trend, but a very marked seasonal variation becomes evident. This seasonal movement is of particular interest because it is quite different from that apparent in the first two years. Animals with a lower average age at slaughter are slaughtered earlier in the year, August–September not October–November, and follow immediately after the slaughter in June and July of animals with a high average age.

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TABLE 16—*Estimated average age of home-bred cattle at slaughter (months)*

Census months		Total	Steers	Heifers
1940	June	35·7	34·1	38·6
	September	36·6	34·4	38·8
	December	36·0	34·0	38·0
1941	March	36·1	35·0	38·1
	June	36·4	34·5	39·4
	September	37·3	35·0	39·6
	December	37·2	35·0	39·0
1942	March	38·2	36·6	41·0
	June	37·4	36·0	41·1
	September	38·6	36·2	42·0
	December	39·2	35.7	43·0
1943	March	38·9	36·2	44·0
	June	38·6	35·8	44·7
	September	37·8	35·0	41·3
	December	39·4	35·0	42·6
1944	March	39·0	36·6	43·6
	June	39·1	36·3	44·0
	September	38·9	36·2	41·3
	December	39·7	36·0	42·0
1945	March	39·7	37·5	43·4
	June	40·2	37·0	45·0
	September	39·4	37·1	41·4
	December	39·7	37·0	41·3

(2) *The number of home-bred cattle purchased for slaughter.*—The number of home-bred steers and heifers purchased for slaughter in 1940 is 823,000, a figure which has never been equalled. After 1940 there is a progressive decline until a figure of 641,000 is reached in 1944. Slaughterings in 1945 show a slight recovery to 696,000, but even this total is 15 per cent. lower than in 1940. The figures in Table 17 below show that there are well-defined seasonal variations in the number of cattle marketed.

TABLE 17—*Total home-bred cattle purchased for slaughter (thousands)*

	1940	1941	1942	1943	1944	1945
Total	823	778	739	643	641	696
December–February	173	188	115	104	89	92
March–May	200	209	217	208	197	173
June–August	169	186	183	185	169	197
September–November	281	195	224	146	186	234

The seasonal pattern is consistent with the general feeding practice described previously in this paper. One period of heavy slaughterings, September–November, occurs at the time when fat beasts are coming off the Summer pastures, and a second period occurs, March–May, as cattle are sold after a Winter spent in stalls and yards. As is to be expected, fewer animals leave the herds between June and August when grass is most plentiful. This seasonal pattern is perfectly clear in the years 1940 and 1941, but in later years it becomes considerably distorted. The most striking change is the fall in slaughterings after 1941 in the December–February quarter; after a figure of 188,000 recorded in 1941, it falls to 115,000 in 1942 and by 1944 is only 89,000. It is clear that something has occurred to dislocate the out-turn of stall-fed cattle, for in striking contrast the March–May slaughterings show practically no fall.

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(d) *Losses to herds due to natural causes*

The final factor influencing the size of the beef population is the loss of stores due to accident and illness. In studies of vital statistics the number of deaths is known through the normal registration of births and deaths, but for cattle no records are kept of deaths due to natural causes. It follows, therefore, that the required information has to be obtained from data collected for other purposes.

A method of estimating the number of natural deaths of beef cattle has been devised using statistics relating to the purchase of cattle hides. The Leather Control of the Board of Trade has purchased all cattle hides since January 1941, and statistics of the numbers obtained are available for each month since that date. The numbers acquired from sources other than the Ministry of Food average about 10 per cent. of the total, and are therefore an important factor in considering herd losses.

After a careful examination of the statistics the total figure of natural deaths is distributed amongst the three classes (beef steers, beef heifers, and milk cattle) in proportion to the mean populations at the appropriate census dates. The resulting figures together with "casualty" slaughterings are shown in Table 18 below.

TABLE 18—*Estimated natural deaths of beef steers and heifers* (*thousands*)

	Total	Steers	Heifers
1940	52	25	27
1941	56	27	29
1942	55	29	26
1943	64	33	31
1944	69	34	35
1945	69	33	36

(3) *The relation between home-bred and imported stores*

It has already been shown that the practice of importing Irish store cattle for fattening on Great Britain farms is a normal peace-time feature of the beef industry. But before December, 1939, it is not possible to determine with any precision the number of Irish animals involved. The new data and the methods employed in this paper now make such a comparison possible.

So far in this analysis the home-bred and imported cattle populations have been considered separately. It now remains to examine the relationship between the two classes of animals and the changes occurring during the war period.

(a) *The number of home-bred and imported stores on farms*

At the December 1939, census, the first held after the outbreak of war, the number of beef stores returned is 1·08 million. Included in this figure are 231,000 imported cattle—just over 21 per cent. of the total. During the next twelve months the number of imported stores is almost unchanged, but the number falls abruptly in 1941 with the cessation of imports, and this class is only saved from extinction by the delayed slaughterings. With the resumed imports the proportion rises to its former level within a period of twelve months, and by December 1942, is nearly 22 per cent. of the total population. These changes are shown in Table 19 below:

TABLE 19—*Estimated number of home-bred and imported stores on farms at the December census* (*thousands*)

	Total	Home-bred	Imported	Per cent. imported
1939	1,078	847	231	21·4
1940	1,121	888	233	20·8
1941	979	944	35	3·6
1942	1,096	859	237	21·6
1943	1,180	905	275	23·3
1944	1,295	1,018	277	21·4
1945	1,357	1,038	319	23·5

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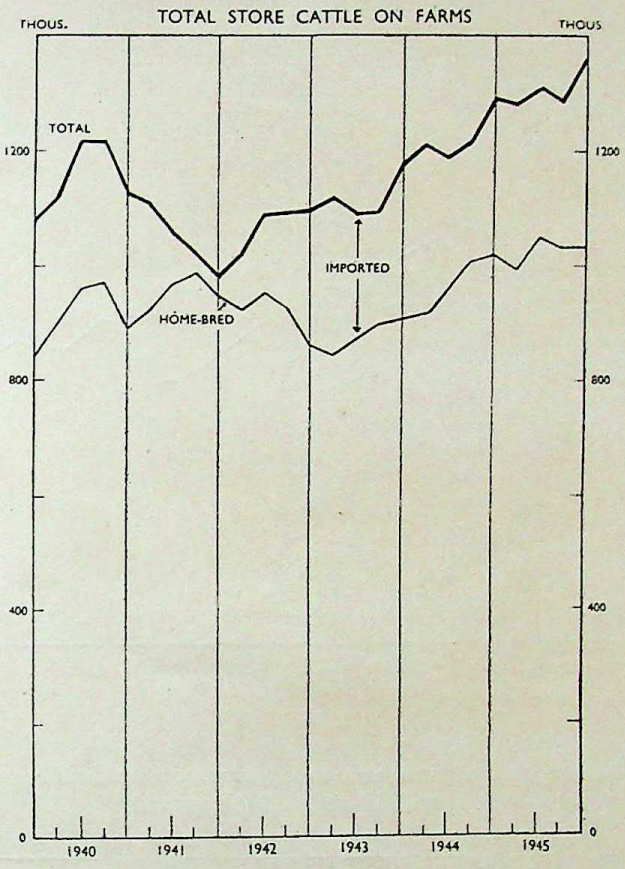
The graph shows very clearly the effect of the eight months' prohibition of imports. By December 1941, the total store population (imported and home-bred together) has fallen to 979,000, so that the animals available for Winter feeding are 142,000 less than the year before—a drop of 13 per cent. Furthermore, this figure of 979,000 is achieved only by delaying the slaughter of a number of home-bred and imported cattle. The graph illustrates how the home-bred population rises during this period, reaching 984,000 in September 1941, and thus interrupting the downward trend of the curve which was noted in Table 9. Both the imported and the home-bred population contribute to the herd expansion evident from December 1941, onwards, and at the end of 1945



GRAPH 3

Irish cattle make up nearly 24 per cent. of population. Thus despite a rapid increase in the numbers of all cattle on farms, the relative position of Eire stores has been more than maintained.

The preceding paragraph shows that about one in every five fattening stores in Great Britain is of Eire origin. It is now necessary to study the steers and heifers separately. Table 20 and the graphs make the position very clear.

Further, it is interesting to note that the part played by the two classes of imported animals in the last six years is quite different ; imported steers are used to a much greater extent in building up the herds.

The table shows that during the six years December 1939, to December 1945, the steer population has increased by over 70,000 compared with an increase of 208,000 heifers. But of this 70,000 increase in the number of steers, 50,000 is attributable to Eire stores and only 20,000 to home-bred animals. The heifer population, on the other hand, has relied mainly on home-bred stores, for of the 208,000 increase since December 1939, only 36,000 is attributable to imports.

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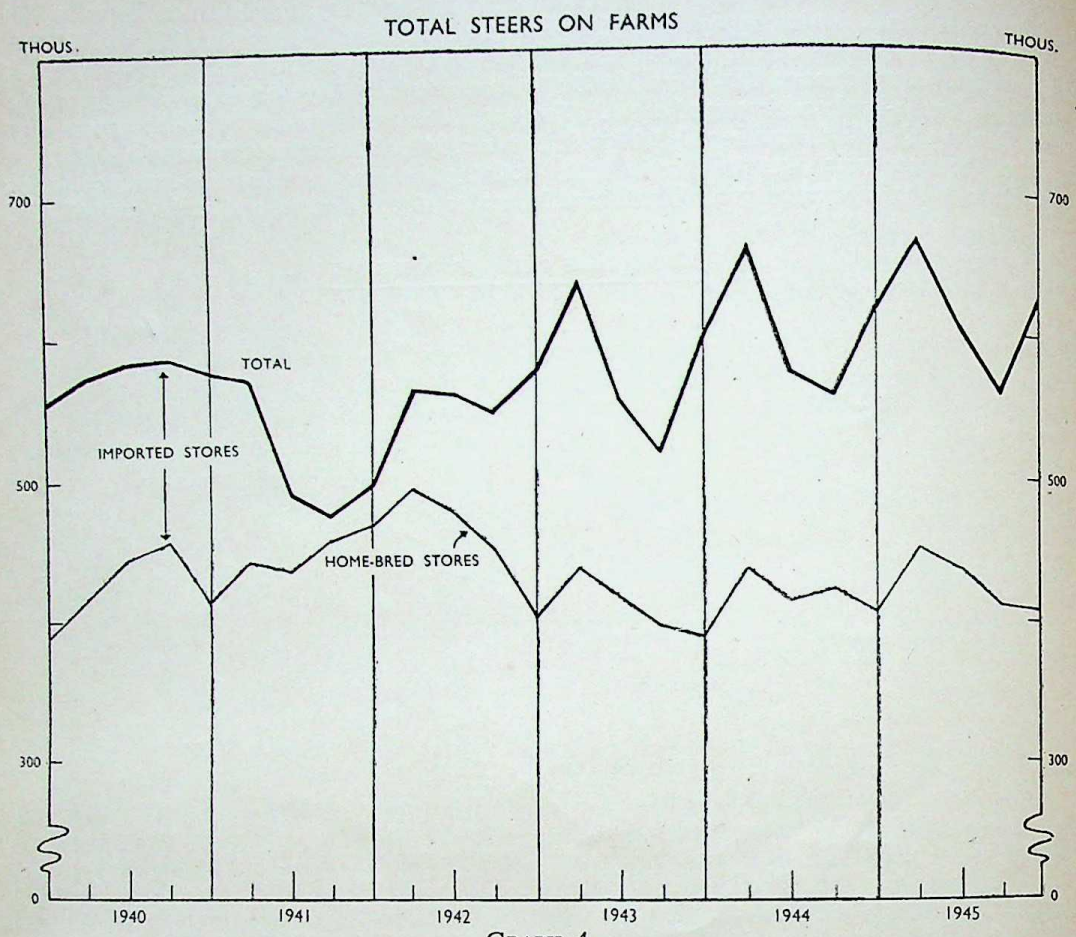

GRAPH 4

TABLE 20—*Changes in the steer and heifer populations at the December census between* 1939 *and* 1945 (*thousands*)

	Steers			Heifers		
	Total	Home-bred	Imported	Total	Home-bred	Imported
1939	(554)	(389)	165	(524)	(458)	66
1940	576	412	164	545	476	69
1941	494	466	28	485	478	7
1942	575	401	174	521	458	63
1943	595	387	208	585	518	67
1944	619	406	213	676	612	64
1945	625	408	217	732	630	102
Increase over 1939	71	19	52	208	172	36

(b) *Inflow of home-bred and imported stores to the beef herds*

The data now accumulated allow a complete survey to be made of the number of stores entering the beef herds in Great Britain. The changes between 1940 and 1945 are summarized in Table 21 below. In the year 1940 farmers received from all sources a total of 1·36 million young animals.

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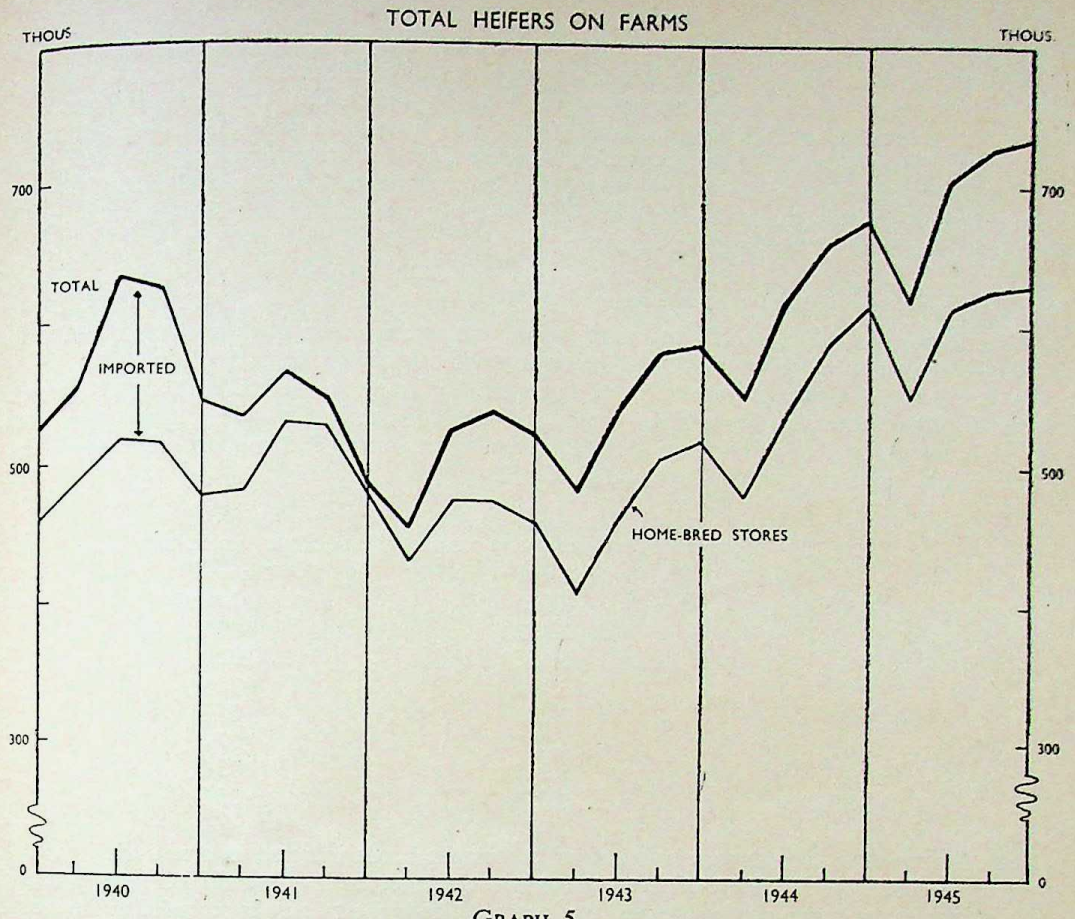

GRAPH 5

This inflow is greater than in any other war year, and exceeds the 1945 inflow by 245,000, or 18 per cent.

The total store population rises steadily after December 1941 (see Table 19), and in view of this fact it is rather surprising to find so little change in the rate of inflow. This suggests that it is the increased "expectation of life" rather than the number of new entrants which is responsible for the expansion of the store population.

TABLE 21—*Estimated total inflow to beef herds* (*thousands*)

	1940	1941	1942	1943	1944	1945
Total	1,362	949	1,077	1,062	1,115	1,117
December–February	340	266	177	176	174	136
March–May	400	269	339	305	307	316
June–August	275	219	249	290	298	277
September–November	347	195	312	291	336	388

In the first four years cattle enter the herds in greatest numbers in the Spring (March–May), but in 1944 and 1945 it is interesting to note that the peak has moved to the Autumn quarter. From 1942 onwards entries in the Winter (December–February) are very low indeed– in 1945 less than half the numbers taken in the other three quarters.

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SECTION III.—BEEF AND DAIRY COWS

It is not possible from the census data to separate the true dairy cows from the cows in the beef herds which are maintained for their calves and not for their milk. This fact is of particular importance when the average length of life in the herds is under consideration. It is generally understood that cows kept for the production of commercial beef stores live longer than the deep-milking dairy cows as they are normally subject to fewer ailments. It follows, therefore, that the average period spent in the herd calculated for both types of cows together is likely to be higher than that calculated for the dairy cows alone.

(a) *Change in the number of cows on farms*

This category is made up of two classes of mature female cattle distinguished in the census returns—"cows and heifers in milk" and "cows in calf but not in milk."

At the June 1939, census the number of dairy and beef cows is 3·08 million. After six years of war this figure reaches 3·25 million—a rise of 174,000, or nearly 6 per cent. The highest June total is, however, reached in the year 1944, when the herd numbers 3·29 million. This movement in the population is summarized below in Table 22.

TABLE 22—*Number of beef and dairy cows at June census (thousands)*

	Number	Per cent.
1939	3,075	100·0
1940	3,102	100·9
1941	3,156	102·6
1942	3,132	101·9
1943	3,270	106·3
1944	3,291	107·0
1945	3,249	105·7
1946	3,250	105·7

The figures show that despite wartime influences the herds increase in size during the first two years. The slight decline evident in the next twelve months is arrested after mid-1942, and the numbers increase steadily for the next two years. The highest figure is recorded at the census taken in December 1943.

The taking of a quarterly census proves that there is a seasonal movement in the population curve. Although the uneven wartime recruitment sometimes obscures the pattern, the population appears to be lowest at the March census, and at a peak in September.

(b) *Changes in the inflow of heifers to dairy and breeding herds*

Young animals for the herds will normally be recruited from the yearling heifers, which are assumed to be mated about the age of 21 months. If the reservoir of home-reared animals fails to provide the requisite number of suitable heifers, the demand is satisfied by importing milk cows or "springers" from Northern Ireland and Eire.

The drive for increased milk production brings recruits from a further class—heifers aged two years and over which are diverted from beef production. The statistics show that both home-reared and Eire beef heifers have been involved in this transfer.

In the discussion that follows the home-reared and imported animals are studied separately. To make these estimates the method described in Section I is again used.

(1) *Inflow of home-reared heifers.*—For the purpose of this enquiry a heifer is deemed to enter the milk or breeding herd when it calves and comes into milk for the first time. The estimated number of heifers calving during each quarter is shown below for the period 1940–1945.

The table shows that the highest annual inflow is in 1940—nearly 780,000 heifers are estimated to enter the herds in that year, 41,000 more than any other annual period for which data are available. In 1941 entries fall sharply to 609,000, a drop of 170,000 from the 1940 total, but recover to 662,000 in 1942. This recovery continues through 1943, 1944 and 1945, and in the latter year entries reach 738,000.

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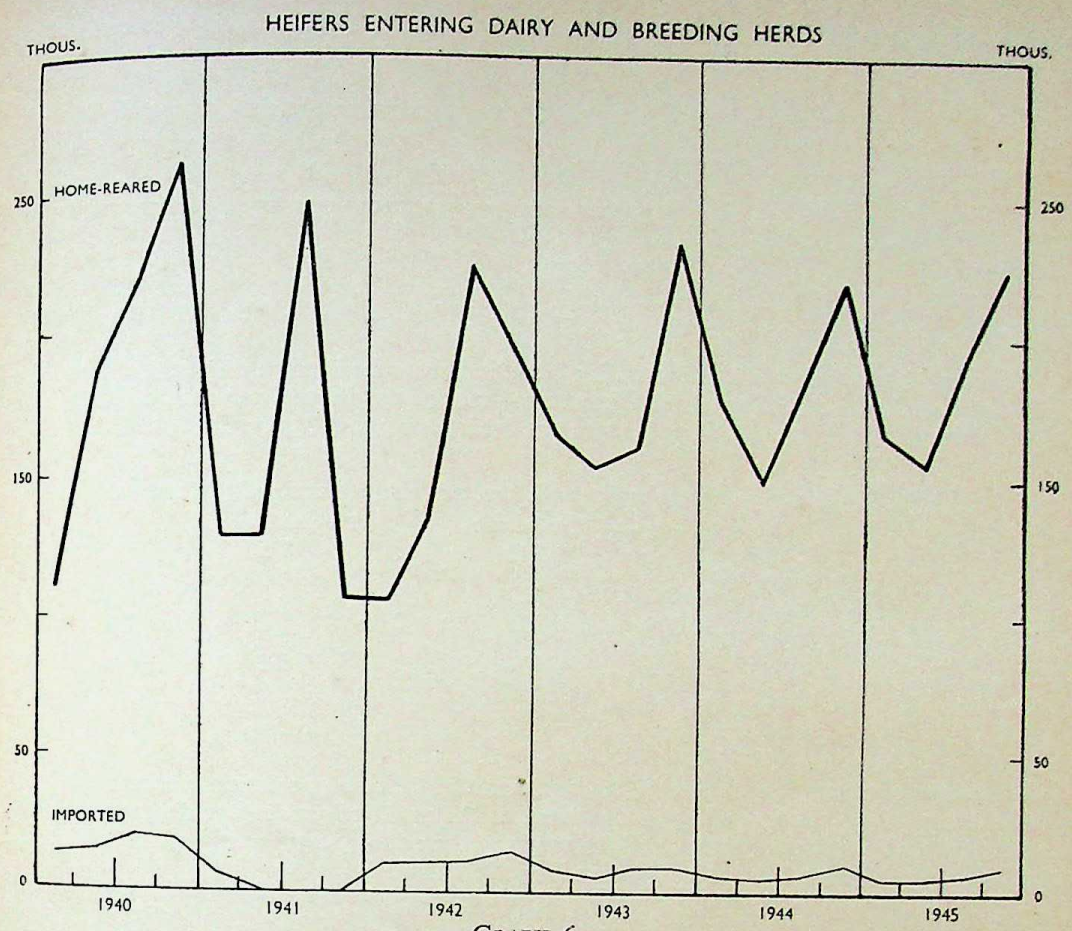

GRAPH 6

TABLE 23—*Estimated number of home-reared heifers entering herds (thousands) (including springers and diverted Eire beef heifers).*

	1940	1941	1942	1943	1944	1945
Total	779	609	662	712	728	738
December–February	111	128	105	165	178	166
March–May	187	128	136	153	147	155
June–August	220	247	225	160	184	193
September–November	261	106	196	234	219	224

The table also shows that entries are very seasonal. In all years except 1941 and 1942 the peak inflow occurs in the Autumn quarter. However, as the graph shows, the trough occurs either in the Winter or the Spring—four times in the Winter quarter (December–February), and twice between March and June. Thus the Autumn calving of first-calf heifers is not purely a wartime phenomenon introduced in response to the Winter milk campaign—heifer calvings in September–November 1940, actually exceed the number in any later war year.

(2) *Imported milk cows.*—The number of milk cows imported in 1940 from Eire and Northern Ireland is 63,000. This is very high compared with the figures for later war years, 1943–1945, which average about 25,000. Since 1942 the imports have been largest in the Autumn, but throughout the period imports in the second half year, June–November, have been in excess of

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those in the first half-year. The emphasis on Winter milk is therefore again apparent in these figures.

TABLE 24—*Imports of milk cows from Eire and Northern Ireland* (*thousands*)

	1940	1941	1942	1943	1944	1945
Total	63	6	43	28	24	22
December–February	12	6	9	7	5	4
March–May	14	—	9	5	4	4
June–August	20	—	11	8	6	6
September–November	17	—	14	8	9	8

The total inflow to the milk and breeding herds is summarized below. The table shows that imported animals are not of any great importance—making up about 7 per cent. of the total in 1940. During the war period this percentage has declined to about 3 per cent.

TABLE 25—*Total entries to milk herds and percentage imported* (*thousands*)

	Total entries	Per cent. imported
1940	842	7·5
1941	615	1·0
1942	705	6·1
1943	740	3·8
1944	752	3·2
1945	760	2·9

(c) *Deaths of beef and dairy cows*

Since exports of cows are negligible, the outflow from the cow population is accounted for by deaths. In addition to those dying on the farms as the result of accident or disease, cows may be slaughtered if they become poor milkers or are not producing satisfactory calves. The total number of cows dying each year is shown in Table 26 below.

TABLE 26—*Estimated annual wastage of beef and dairy cows* (*thousands*)

	Total deaths	Deaths as per cent. of population
1940	714	22·7
1941	720	22·6
1942	592	18·6
1943	676	20·6
1944	798	24·2
1945	799	24·6

It is interesting to compare these figures with some published material. Two investigations by milk-recording societies which bear upon the annual wastage of dairy cattle have been undertaken by the School of Agriculture, Cambridge University, and by the National Institute for Research in Dairying at Reading. The results of this enquiry are given in a report prepared in 1934 and the average figure arrived at is 22 per cent. Similarly a paper published by Dr. Norman Wright* gives an estimate of 23·5 per cent. On the basis of this and other evidence the Committee on Cattle Diseases reaches the following conclusion: "It may however be asserted with some confidence that an annual wastage of less than 20 per cent. or of more than 25 per cent. is very improbable."†

The figures in Table 26 above are a remarkable confirmation of these earlier estimates. Nevertheless, it is clear that given abnormal conditions, these wastage rates may fluctuate to a considerable extent. In 1942 the annual wastage falls to 18·6 per cent., and in 1943 to 20·6 per cent.,

* *Scottish Journal of Agriculture*, 16, No. 1, January, 1933
† Committee on Cattle Diseases. Cmd. 4591, p. 113

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both well below the average. As the cow population is expanding in this period it suggests that some poor milkers due for disposal may be retained for a further lactation and thus reducing the wastage rate. It must be remembered that cows in their final lactation are not put in calf in the usual way, but are dried off and subsequently fattened. Disposals planned by herd owners in this way can be accurately measured, since the animal is purchased by the Ministry of Food and slaughtered for beef. The only exception to this is a cow unfit for beef which is disposed of through the knackers—normally one of considerable age. It is possible, therefore, to roughly divide the deaths of cows into two classes—those deliberately planned by herd owners and those occasioned by accident on the farm, extreme old age, or disease making the carcase unfit for human consumption. It is to be expected that any change in the wastage rate due to government policy will be reflected in the figures of deaths planned by herd owners, rather than in the figures of death from "natural causes." The analysis set out below shows that this is in fact the case, accidental deaths remaining between 6 and 7 per cent. throughout the six-year period. The planned disposals, on the other hand, vary between 12·5 per cent. and 18·5 per cent.

TABLE 27—*Deaths of cows due to slaughter and natural causes (thousands)*

	Death due to—		Percentage due to—	
	Slaughter for beef	Natural causes	Slaughter for beef	Natural causes
1940	530	184	16·9	5·9
1941	528	192	16·5	6·0
1942	398	194	12·5	6·1
1943	457	219	13·9	6·7
1944	584	214	17·7	6·5
1945	601	198	18·5	6·1

In 1940 deaths of beef and dairy cows are estimated at 714,000, and in 1941 at 720,000. This represents an annual wastage of 23 per cent. The abrupt fall in total deaths which takes place in 1942 is due entirely to a reduction in the number of cows "culled" from herds. Only 12·5 per cent. of cows in the herds are sold for slaughter in that year compared with 16·5 per cent. in 1941. This reduced death rate is, however, only temporary. In 1945 the number of cows disposed of rises to over 600,000, or 18·5 per cent. of the population. These higher rates for 1944 and 1945 suggest that some of the cows kept beyond the normal term may now be leaving the herds.

The rate of disposal of cows shows marked seasonal variations. Cows leave the farms in greatest numbers in the Autumn, and this seasonal peak has been prominent throughout the war. The period of lowest "culling" is the March–May quarter. The high Autumn "cullings" indicate that cows (particularly Spring calvers) tend to leave the herds as grass becomes scarce and it is necessary to change from Summer feeding to the more expensive Winter feeding. These figures are shown below.

TABLE 28—*Number of cows and heifers culled from herds (including cow-heifers) (thousands)*

	1940	1941	1942	1943	1944	1945
Total	530	528	398	457	584	601
December–February	118	126	87	106	140	151
March–May	112	115	78	89	103	90
June–August	130	143	92	104	123	136
September–November	170	144	141	158	218	224

The estimate of the number of deaths from accident and disease has been obtained by the method described on p. 206. To these figures are added a proportion of the "casualty slaughterings" recorded by the Ministry of Food. These estimates are given in Table 29 below for each quarter since December 1939.

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TABLE 29—*Estimated number of cows dying from natural causes* (*thousands*)

	1940	1941	1942	1943	1944	1945
Total	184	192	194	219	214	198
December–February	43	42	44	57	58	52
March–May	64	66	56	59	57	56
June–August	40	44	41	44	45	41
September–November	37	40	53	59	54	49

The table shows that roughly 200,000 cows a year are lost from accident and disease—between 6 and 7 per cent. Deaths are at a peak in the March–May quarter—although this feature has been less apparent since 1943. The high death-rate at this time of the year may be a joint effect of casualties during calving and the lowered resistance of cows housed during the Winter. This is, moreover, borne out by the enquiry into knacker slaughterings undertaken by the Department of Animal Health, Aberystwyth.* It is stated there that the presence of a Spring peak is "in agreement with the general observation of veterinary practitioners, and also with the well-known fact that farm animals are in their poorest condition during the late Spring months."

There is one further point that should be noted. Deaths due to natural causes are estimated here at about 6 per cent. of the total cow population. This estimate is much higher than the estimates for cattle over one year old previously quoted in reports made by the Agricultural Departments, which are generally in the region of 2 per cent.† It is a little difficult to explain this discrepancy, but it is probably largely a matter of definition. In these earlier enquiries farmers are asked to state the number of cows which have died on the farm, whether killed outright after an accident, or as a result of illness or at calving. Thus cows disposed of to knackers and the Ministry of Food with broken bones or with evidence of disease will not be included with farm deaths, although the disposal is still attributable to natural causes.

SECTION IV—HERD REPLACEMENTS

Cattle being reared as replacements for the beef and dairy herds appear in the census returns under three headings: cattle under one year old, cattle one year old and under two, and heifers-in-calf with first calf. Data regarding the sex of the replacement classes are not complete for cattle under one year old, and for this reason the analysis that follows will not differentiate between steers and heifers.

Earlier in this paper the estimated number of young cattle passing into the beef and milk herds has been analysed in detail. For the purpose of this enquiry the beef yearling passes into the beef store herd at the age of two years, and (with the few exceptions already noted) a heifer calves and enters the milk and breeding herds about the age of two years six months. When this material is assembled much new information becomes available. Since the month of entry to the beef and milk herds can be assumed, it follows that the month of birth of each group of animals can be determined. Further, the method described in Section I, but used in reverse, may be employed to construct an age distribution and so to estimate a population. However, here it is important to note that the total so obtained is not equivalent to the census population, but represents the "surviving population" or the number of animals which actually survive to maturity.

It is at this point that the results of the chain of deductive reasoning are subject to the first important check, and later in this section the recorded and the estimated numbers will be compared. It is now proposed to examine the " replacement" population as recorded at the quarterly census, following this with a description of the estimated "surviving population."

(1) *The number of replacement cattle*

In June 1939, the young cattle on farms in Great Britain number 3·79 million—exactly the level of the year before. In the next twelve months the number rises by nearly 4 per cent. to 3·93 million, but later falls back to 3·83 million. Between 1941 and 1944 the numbers rise steadily,

* *Nature*, June 15, 1946, p. 809.

† *The Agricultural Output of England and Wales*, 1930–31. Cmd. 4605, p. 17. *Agricultural Statistics*, 1938. Department of Agriculture for Scotland, p. 66.

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and in 1944 are just above four million. No change in the total is recorded between 1944 and 1945. These changes are shown below in Table 30. Bull calves are included, as no record of their number is available before December 1939.

TABLE 30—*Total number of replacement cattle on farms at the June census (thousands)*

	Number	Per cent.
1938	3,791	100·0
1939	3,791	100·0
1940	3,934	103·8
1941	3,831	101·1
1942	3,910	103·1
1943	3,939	103·9
1944	4,009	105·8
1945	4,009	105·8
1946	4,004	105·6

Within the replacement group the heifers in calf constitute the most distinct class. These heifers remain in this class for nine months (that is, for the period of gestation), and on calving enter the dairy and beef herds. The number of heifers in calf at each census date may be estimated, taking in account the required inflow to the milk herds and the nine months of gestation. Throughout the period the estimates obtained in this way prove to be lower than the numbers recorded in the census. The reason for this discrepancy can only be conjectured, though the following facts are certainly relevant. Firstly the estimates relate only to heifers (including imported springers) that calve successfully and enter the milk herds; they exclude heifers that slip their calves or that die during the gestation period. For this reason the estimates are bound to be slightly lower than the actual counts of in-calf heifers at any time. Secondly, in making his returns for the census, a farmer may not always be certain whether or not his heifers are in calf. It is customary on some farms to run the bull with a number of heifers, and it is possible that the farmer may assume that all such heifers are in calf, without a complete check. This would explain a certain degree of inflation in the figures. The recorded June figures and the estimates are compared in Table 31 below.

TABLE 31.—*Heifers in calf at the June census (thousands)*

	Returned at the census	Estimated	Difference
1940	596	594	— 2
1941	552	456	— 96
1942	751	570	— 181
1943	729	562	— 167
1944	744	558	— 186
1945	747	570	— 177

It is interesting to note that the gap between the two series of figures grows larger after the early months of the war. However, the graph shows that the estimated totals have much the same seasonal pattern as the recorded figures. The fact that the two series are in close agreement in the early months of the war suggests that the discrepancy in later years is due to some new circumstance. It is possible that farmers undertaking wartime milk production may be less accurate in their observation than hitherto due to lack of labour or lack of experience, and this may go some way to explain the apparent inflation. In the analysis that follows, the estimated series is the one used. The surplus heifers in calf are returned to the yearling heifer class.

Earlier in this section it is noted that the method described in Section I(3), but applied in reverse—the animals getting younger instead of older—may be employed to ascertain for any date both the size and the age composition of one sector of the replacement population. This population is made up of all the young animals required in the following two years as replacements for the beef and dairy herds; it includes only those animals which are *known* to enter these two classes. Two things follow naturally from this: (*a*) The population so obtained is net of deaths —by definition any calf or yearling dying before it leaves the replacement group is excluded, and

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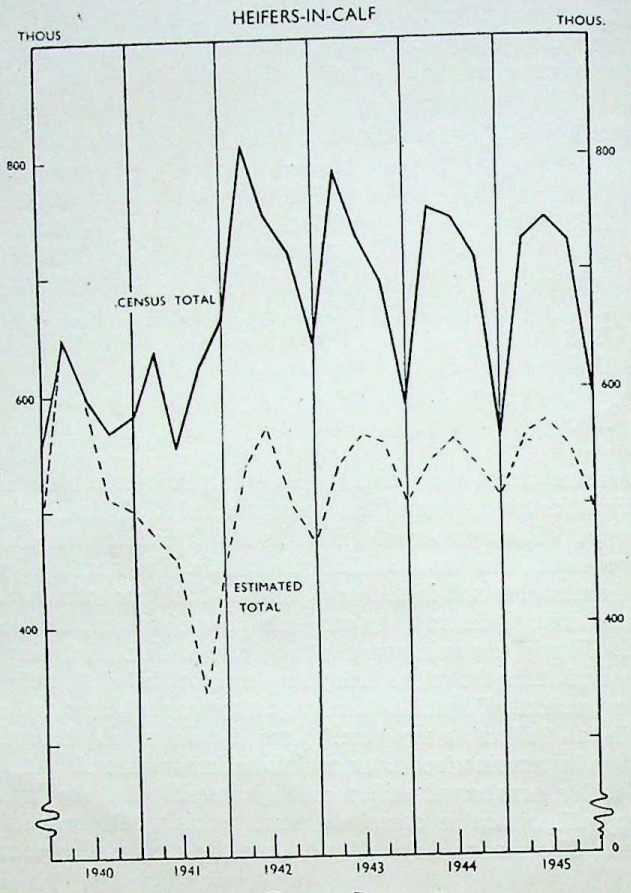

GRAPH 7

(*b*) the numbers in this population, if correctly determined, will always be fewer than the numbers in the census population.

Since it consists only of young cattle known to survive to maturity this sector of the replacement population is called for convenience the "surviving population," and similarly the calves and yearlings which are included at the census but nevertheless do not survive the first two years of life are called the "non-surviving population."

The "surviving population" so constructed for any census date is a synthesis of all the data on flows and wastage of cattle available to the statistician. It summarizes in one series of figures the reliance of the beef and dairy population on home-reared young stock; it shows, for instance, that at June 1940, 2·75 million replacement cattle, aged 0–23 months, are required in the next two years to meet the requirements of the milk and beef herds (allowance being made for imports). It is clear, therefore, that the corresponding census figure will be considerably larger, since it will include some veal calves and some other animals that will be lost later from accident and disease.

If the estimated number of "surviving" replacement cattle should prove to be larger than the census number, then it is clear the figures of inflow to the beef and dairy classes must be inflated. Thus the method of estimation is subject to an important check at this point. In Table 32 below the "surviving population" and the total replacement populations are compared.

The comparison proves that the estimates of inflow to the various groups are most unlikely to be inflated, since the "surviving population" is consistently below the census population. They might, however, be too low. Fortunately a further check may be made using the statistics of "calves for rearing" obtained from farmers in the early years of the war, and these confirm the earlier results.

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TABLE 32—*Analysis of replacement population at the December census (thousands)*

	Total	"Surviving"	"Non-surviving"
1939	3,214	2,845	369
1940	3,270	2,625	645
1941	3,190	2,585	605
1942	3,221	2,737	484
1943	3,256	2,800	456

It may reasonably be concluded therefore that the estimates of the size of the "surviving replacement population" and thus of the inflow figures to the beef and dairy population are subject to little error and can be used with a considerable degree of confidence.

(2) *The estimated number of calves born*

In making these estimates two classes of calves may usefully be distinguished: calves born to heifers with their first calf, and calves born to cows and heifers which have been in the herd for one year or more.

Theoretically the method of estimation used here should proceed in two stages, firstly ascertaining the number of calvings, and secondly, relating this figure to the number of calves born. However, the assumptions made in this second stage are purely arbitrary, as no information is available relating to the proportion of live births resulting. It is therefore assumed that calvings are equivalent to births. This assumption, which has the merit of simplicity, also means that the estimates are readily adjustable whenever more information on this subject becomes available.

In making this distinction between first and later calvings, the problem of estimating the total calvings is much simplified. It has already been seen that a heifer is deemed to enter the milk or breeding herd when it calves and comes into milk for the first time. The number of such heifers is given in Table 23, and, making the arbitrary assumption mentioned above, the estimate of calves born is immediately available. The problem that remains to be solved is the estimation of second and later calvings.

Certain assumptions regarding population wastage and the length of the calving cycle must be made before embarking on this final set of estimates, and these are as follows:

(1) The average length of time between calvings is thirteen months.

(2) The slaughter of cows by the Ministry of Food other than "casualties" measures the culling of sound cows after their final lactation.

The milk cow population may now be roughly distributed according to the time period between the census and the estimated calving date; that is to say, so many cows are due to calve in less than one month, so many in less than two months and so on. For a number of reasons not all the cows recorded at the opening date will calve in the succeeding twelve months. In the first place, if the calving cycle is taken as thirteen months, one-thirteenth of the total will still be in-calf at the closing date. Secondly, a number of cows are in their final lactation and will be slaughtered on its completion ; these cows also will not calve. Thirdly, and finally, the number of calvings will be affected by deaths amongst the in-calf cows. Taking all these factors into consideration, and using the assumptions listed above, the number of cows calving within the herds may be estimated for all years from 1940–1945. To these estimates must be added the calvings of young heifers with their first calf, and the resulting figures are given in the table below.

TABLE 33—*Estimated number of cows and heifers calving in Great Britain (thousands)*

	Total calvings	Heifers with first calf	Other cows and heifers
1940	3,128	779	2,349
1941	3,077	609	2,468
1942	3,110	662	2,448
1943	3,133	712	2,421
1944	3,179	728	2,451
1945	3,073	738	2,335

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The number of calvings is estimated at 3·13 million in 1940, falling to 3·08 million in 1941. After this year the numbers rise steadily until 1944, when they reach 3·18 million. This high figure is rather to be expected because the cow population reaches its highest war-time level in that year. In 1945 a decrease is shown in the number of calvings within the herds, probably due to the higher rate of cullings (see Table 28).

It has already been noted that the entry of new heifers into the milk herds conforms to a regular seasonal pattern with the peak in the Autumn. The calvings of cows within the herds, as is generally recognized, show an equally marked seasonal movement, but here the peak period is the Spring. These combined estimates are given in Table 34 below.

TABLE 34—*Estimated number of calvings in Great Britain (including springers) (thousands)*

	1940	1941	1942	1943	1944	1945
Total	3,128	3,077	3,110	3,133	3,179	3,073
December–February	672	729	706	718	803	768
March–May	930	896	947	940	883	902
June–August	691	791	739	670	709	651
September–November	835	661	718	805	784	752

(3) *The disposal of calves born in Great Britain*

It now remains to examine the disposal of these calves, and it is proposed, therefore, to compare the numbers reared with those dying on the farm or from slaughter. The table below gives the general position for 1940–1943, the only years for which full data are yet available.

TABLE 35—*Analysis of calves born in Great Britain* 1940–1943 (*thousands*)

	Total	Reared to maturity	Loss from deaths or slaughter
1940	3,128	1,437	1,691
1941	3,077	1,445	1,632
1942	3,110	1,539	1,571
1943	3,133	1,519	1,614

The table above shows that half the calves born are reared for the beef and dairy herds, the remainder dying some time between birth and the age of two years.

(a) *The number of calves reared*

With the exception of a few specially selected for breeding, male calves are reared as beef stores. Female calves are reared either as beef heifers or as breeding heifers. Table 36 below shows the division of the calves reared to maturity into their final categories.

TABLE 36—*Disposal of calves born* 1938–1943 *and reared to maturity on farms in Great Britain (thousands)*

	Total	Male calves			Female calves		
		Total	Beef steers	Bulls	Total	Beef heifers	Breeding heifers
1938	1,623	524	484	(40)	1,099	379	720
1939	1,514	557	517	(40)	957	370	587
1940	1,437	447	408	39	990	272	718
1941	1,445	440	398	42	1,005	323	682
1942	1,539	449	399	50	1,090	401	689
1943	1,519	412	370	42	1,107	380	727

These figures are of particular interest because they give some indication of changes precipitated by the outbreak of war. In 1938 the number of calves reared is about 1·6 million, but the

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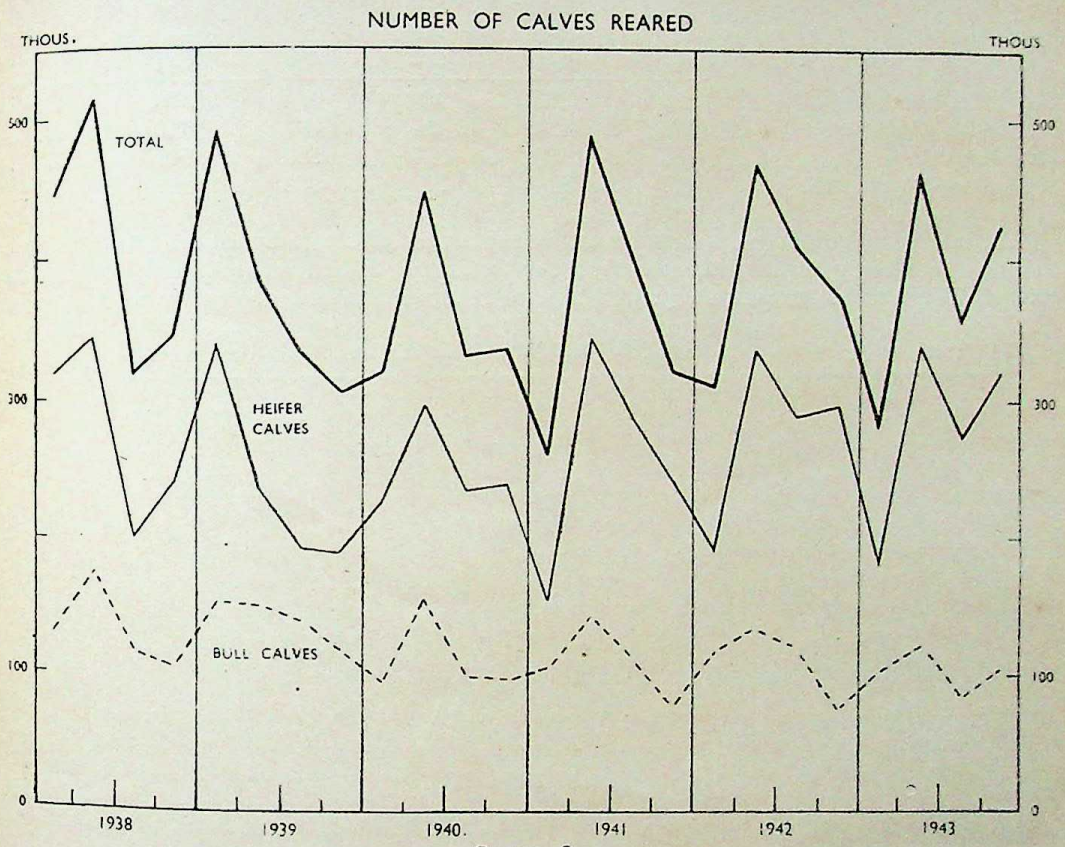
1939 figure is 1·5 million, the drop occurring in the breeding heifer category. The lowest total figure occurs in 1940, when only 1·4 million of the calves born are reared, after which the number rises to 1·5 million in 1943. It must be remembered that female calves may always be diverted from the class for which they were originally intended as replacements. This certainly happens to the group born in 1940. Of the 990,000 calves reared in that year only 272,000 enter the beef store class at the age of two years, although the number originally planned may have been as high as 380,000. This suggests that somewhere about 100,000 yearling heifers are diverted from the store population to the milk population.

The number of steer calves reared for beef rises in 1939 to 517,000, but then declines steadily over the period for which data are available.



GRAPH 8

(b) *The number lost from deaths and slaughter*

It has already been seen that only about half the calves born in Great Britain are reared as beef and dairy replacements. Of the remainder some are fattened and sold as veal calves, but the majority are slaughtered immediately after birth or die from natural causes.

In this section the wastage figures quoted refer to all animals under two years old, as there is no completely satisfactory way of distinguishing the deaths of calves from those of yearlings. The table below shows the wastage amongst calves born in 1940 is estimated at 54 per cent., falling to 51 per cent. in 1943.

The number of natural deaths amongst the replacement population has been estimated in the usual way. Since the number of calves born has already been estimated (see Table 34) and the population movement is known from recorded data, the outflow may be calculated. From this outflow the normal exits of replacement animals to beef and dairy herds must be deducted,

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TABLE 37—*Wastage as percentage of all calves born* 1940–1943

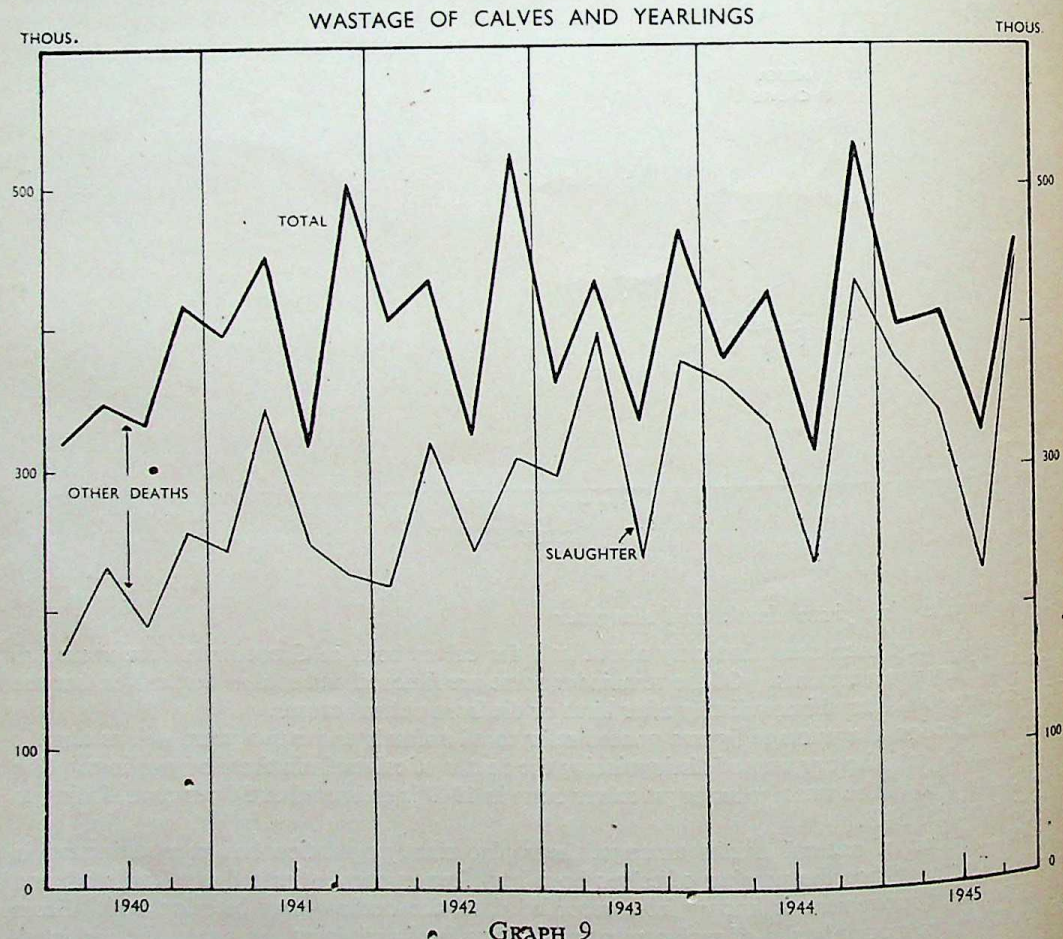
	Total	Loss from deaths or slaughter	Reared to maturity
1940	100·0	54·1	45·9
1941	100·0	53·0	47·0
1942	100·0	50·5	49·5
1943	100·0	51·5	48·6

the residual figure representing loss from natural deaths and slaughter. These estimates are as follows:

TABLE 38—*Estimated wastage of replacement animals (including slaughter)* (*thousands*)

	1940	1941	1942	1943	1944	1945
Total	1,415	1,672	1,692	1,642	1,656	1,595
December–February	318	396	404	363	384	401
March–May	346	452	434	444	425	410
June–August	333	320	327	352	317	326
September–November	418	504	527	483	530	458

The table shows that the death rate is affected to a marked degree by the season of the year. In general deaths are low in the June–August quarter and are highest in the Autumn. The graph compares these estimates with the quarterly figures of calves slaughtered.



GRAPH 9

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(4) *Replacements for beef and dairy herds*

The outflow from the replacement group consists of two classes of mature cattle, stores for the beef herds, and milk heifers for the milk and breeding herds. Estimates of the numbers of young cattle leaving the replacement group are available since December 1939, and the annual totals are shown in the table below.

The total outflow of replacement cattle (excluding bulls) varies between 1·3 million and 1·6 million a year, the highest figure ever recorded being in 1940. The number of store cattle exceeds that of milk heifers in all the war years.

TABLE 39—*Estimated outflow of store cattle and milk heifers* (*thousands*)

	Total	Store cattle	Milk heifers *	Stores as percentage of tota
1940	1,642	863	779	52·6
1941	1,496	887	609	59·3
1942	1,342	680	662	50·7
1943	1,433	721	712	50·3
1944	1,528	800	728	52·4
1945	1,488	750	738	50·4

* Including heifers imported as springers

The table also shows that the ratio between the two classes of replacement cattle is by no means constant.

The outflow of male store cattle at the age of two years is dependent on the number of calves reared two years before. With the rate of mortality in the first two years of life more or less constant, a heavy outflow, as in the year 1941, can only be accounted for by an exceptionally large number of surviving male calves in 1939.

TABLE 40—*Estimated outflow of beef steers* (*thousands*)

	Number	Per cent.
1940	484	100·0
1941	517	106·8
1942	408	84·3
1943	398	82·2
1944	399	82·4
1945	370	76·4

The table shows that the number of beef steers leaving the replacement group in 1945 is the lowest on record, and only 76 per cent. of the 1940 figure.

The outflow of female store cattle on the other hand is governed by a second factor—the competitive pull of the breeding group. This relationship between the two flows is of exceptional interest, for it is one that is particularly sensitive to outside influences. It is clear from the table below that breeding heifers always form the major part of the outflow—in 1940, 67 per cent., and in 1945, 65 per cent. (This flow is measured nine months *before* entry into the milk herds, that is, the flow into the heifer-in-calf class). In 1942/3 the high demand for dairy stock results in about 70 per cent. of the heifers entering the breeding class. The table also shows that in 1942 the high inflow to the breeding class is met despite the small numbers of heifer yearlings available, beef recruits being at the record low figure of 272,000.

TABLE 41—*Estimated supply of breeding and store heifers* (*thousands*)

	Total	Breeding heifers*	Store heifers	Breeding heifers as per cent. of total
1940	1,134	755	379	66·6
1941	926	556	370	60·0
1942	929	657	272	70·7
1943	1,054	731	323	69·4
1944	1,120	719	401	64·2
1945	1,091	711	380	65·2

* Including diverted Eire beef heifers

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In 1942 and 1943 an increase in the outflow to the breeding heifer population appears to have taken place at the expense of the store heifers. This question can be studied in more detail with the help of quarterly figures, and these are given in Table 42 and illustrated by the accompanying graph.

TABLE 42—*Estimated supply of store and breeding heifers (thousands)*

		Total	Store heifers	Breeding heifers *
1940	December–February	359	105	254
	March–May	214	88	126
	June–August	202	74	128
	September–November	359	112	247
1941	December–February	198	92	106
	March–May	232	129	103
	June–August	221	90	131
	September–November	275	59	216
1942	December–February	197	9	188
	March–May	271	108	163
	June–August	220	69	151
	September–November	241	86	155
1943	December–February	230	—	230
	March–May	291	115	176
	June–August	259	113	146
	September–November	274	95	179
1944	December–February	226	12	214
	March–May	286	122	164
	June–August	279	125	154
	September–November	329	142	187
1945	December–February	211	—8	219
	March–May	283	121	162
	June–August	275	111	164
	September–November	322	156	166

* For bulling. Including some diverted Eire beef heifers in 1943 and 1944

The table and the graph show very clearly how the maintenance of the inflow to the breeding population has reduced the number of beef recruits. But the most interesting point is the seasonality of this transfer. From 1941 onwards the high Winter outflow of breeding heifers is always accompanied by a drastic fall in the outflow of beef heifers; in the four last years under consideration they have numbered 12,000 or under. However, this diversion is largely restricted to this period of the year because the Spring and Summer outflow to the beef herds does not appear to be affected.

(5) *Summary*

At this point the statistical analysis of the natural cycle of growth and reproduction is completed and the various movements within the total population are presented in broad outline. A recapitulation of the movements in the year 1942 may serve to illustrate the completion of the statistical balance sheet. In Table 43 below the total population is given at the beginning and end of the year 1942, with the various classes that have been under discussion.

In this year 3·11 million calves are born, and these represent the inflow to the yearling and calf class and also to the bull class (Table 33).

The replacement population (excluding heifers in calf), which numbers 3·19 million at the beginning of the year, provides 1·39 million young animals for replacements in the year, 680,000 going into the beef herds, 657,000 going into the heifers-in-calf class, and 50,000 as bull calves.

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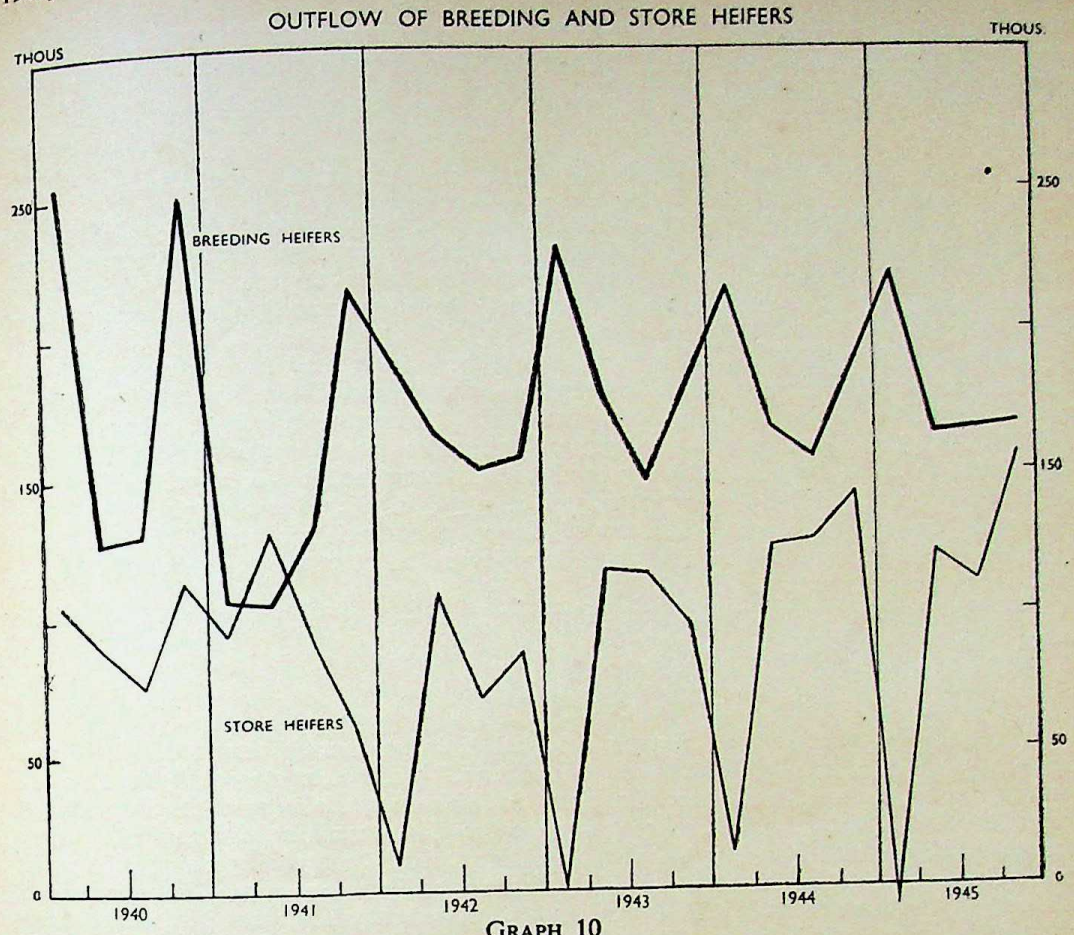

GRAPH 10

TABLE 43—*Number of cattle of farms in* 1942 (*thousands*)

	At beginning of year	At end of year
Total	7,933	8,231
Cows in milk and in calf	3,138	3,251
Bulls and bull calves	176	193
Fattening beef stores	979	1,096
Replacement cattle:		
(*a*) Heifers in calf	450	470
(*b*) Yearlings and calves	3,190	3,221

The wastage from this group over the twelve months—slaughter and natural deaths—amounts to 1·69 million and the live births 3·11 million (imports may be ignored), so that the number of young replacement cattle on farms at the end of the year is 3·22 million (Tables 41 and 38).

The heifers-in-calf class in its turn contributes 662,000 heifers to the milk herds and takes the 657,000 heifers from the replacement group. 25,000 springers are imported.

The beef store population draws 680,000 steers and heifers from the replacement group and 396,000 from imports. The number slaughtered or dying is 960,000, and the population at the end of the year, therefore, numbers 1·10 million (Tables 3, 15, 4, 17 and 18).

In this year the bull population rises from 176,000 to 193,000. It receives 50,000 new recruits and loses 33,000 older animals (Table 68).

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Finally the milk population draws 662,000 from the heifers in calf and 43,000 from imported milk cows. Herd wastage amounts to 592,000, so that the number of milk cows at December, 1942, is 3·25 million (Tables 23, 24 and 26).

SECTION V—VITAL STATISTICS RELATING TO THE CATTLE POPULATION

In the three previous sections data relating to births and deaths are obtained and discussed in relation to the relevant sector of the cattle population; as for example, the wastage of dairy cows. In this final section it is proposed to relate this data to the population as a whole, and so to obtain a series of birth and mortality rates roughly parallel to those familiar in studies of the human population.

In assessing the value of the figures that follow it has to be realized that in most cases either the numerator or the denominator is a derived total—sometimes both—and the accuracy attained cannot approach that obtainable from recorded figures. In particular, it is clear from the discussion in the previous section that the degree of precision in estimating the number of births is considerably less than that attained in other estimates of inflow used in this paper. Nevertheless this analysis of vital statistics has been attempted because it is believed that, despite their serious limitations, the birth and mortality rates are of value in rounding off the study of the population figures and, further, serve to show what could be achieved if a full system of recording births and deaths was ever instituted.

The vital statistics rates are discussed under two heads—death rates and birth and fertility rates.

(1) *Death rates*

In considering the death rates of cattle, a logical distinction may be drawn between deaths that are "intentional" and deaths that are "unintentional." In the first class are fat cattle ready for slaughter as beef, and in the second are cows that die during calving or calves that succumb from illness. It would appear, therefore, that these two classes could be distinguished by using the data relating to cattle slaughtered for food, the "intentional" deaths being the ones to appear in the slaughtering figures. In practice this statistical classification is unsatisfactory and even misleading. In the first place a milking cow may be fattened and slaughtered if it fails to breed or develops some physical defect. Thus the death, though not directly due to accident, is still an item in the "unintentional" wastage, and is extraneous to the general policy of disposal and replacement. Secondly, war-time policy dictated by the shortage of meat has influenced livestock practice. Due to the price incentive, cattle, and particularly calves, may be sold to the Ministry of Food when it is realized that they are ill and unlikely to live; thus they enter into the slaughter figures, where before the war they might have died on the farm or been disposed of through knockers or kennels. In so far as they are termed "casualties" by the Ministry of Food, this class of animal can be distinguished, but so long as they can wait the statutory twelve days the beast will appear amongst the "intentional" deaths. In general, therefore, there is a tendency in war-time for a greater number of diseased or injured cattle to be slaughtered for food, and thus for the ratio of "intentional" to "unintentional" deaths to alter. The apparent lessening degree of "unintentional" wastage as revealed by the statistics is thus largely spurious.

(a) *Crude death rates*

The first death rate to be considered is the crude death rate—taking into account deaths from all causes and at all ages. It is represented as a percentage figure per annum and is computed from the following formula:

$$M = \frac{D}{P} \times 100,$$

where M = crude death rate;
D = total deaths taking place in twelve months' period;
P = total cattle population exposed to risk of death.

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It is desirable to relate deaths to the average population exposed to death over the twelve months period; a mid-year figure is unsatisfactory in view of the marked seasonality in the level of population. The average has been obtained by taking the relevant five census dates—December to December inclusive.

The table below gives the crude death rate for the years 1940 to 1945, firstly for total deaths and secondly for "unintentional" or "natural deaths" in so far as they do not participate in the official slaughtering figures. It is significant that whilst the crude rate for all deaths remains fairly constant, the rate for "natural deaths" falls from about 10 per hundred to 5 per hundred population.

TABLE 44—*Crude death rates*

Number of deaths per 100 population

	All deaths	"Natural deaths"
1940	42·3	9·8
1941	43·1	10·5
1942	40·1	10·3
1943	39·8	7·3
1944	40·9	6·7
1945	40·6	5·5

(b) *Specific death rates.*

Taking the cattle population as a unit, the rates in the first column express the average chance of death from all causes. But it is clear that the chance of death will vary both with the age and function of the animal and more precise information is often required. This may be provided through the calculation of specific death rates, and these are calculated for mature cattle and replacement cattle separately. In each case the deaths occurring are related to the population exposed to risk in the same period. The specific death rates are given in Table 45 below.

TABLE 45—*Specific death rates by age*

Number of deaths per 100 population

	Mature cattle	Replacement cattle
1940	47·1	36·8
1941	42·4	44·0
1942	36·4	44·3
1943	37·5	42·6
1944	39·7	42·3
1945	40·3	41·0

The similarity between the two series of specific rates and again between the specific and the crude death rates is rather interesting; it would appear that the greater risk of death due to slaughter for food in the mature cattle class is balanced by the greater risk of death through calf mortality in the replacement class.

The abnormally high specific death rate for mature cattle in 1940 invites a still more detailed analysis. To do this specific rates have been calculated by function and sex, thus showing store and milk cattle separately.

TABLE 46—*Specific death rates by function and sex*

Number of deaths per 100 population

	Milk and beef cows	Home-bred store cattle		
		All stores	Steers	Heifers
1940	22·7	95·7	114·2	80·0
1941	22·6	88·5	105·2	73·9
1942	18·6	86·3	106·1	66·7
1943	20·6	80·7	104·9	59·8
1944	24·2	74·0	95·6	57·8
1945	24·6	74·4	92·9	61·4

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The table shows that the expectation of life of home-bred store cattle increases very considerably after 1940, the biggest change occurring between 1940 and 1941.

(c) *Calf mortality rates*

The third death rate to be considered is the calf mortality rate. There is no satisfactory method of distinguishing deaths of calves from deaths of yearlings, but an estimate has been obtained by deducting 2 per cent. of the yearling population as representing deaths of yearlings. This percentage is based on information obtained from farmers by the Ministry of Agriculture for Northern Ireland, which shows that the deaths of yearlings on farms average 2 per cent. for the period 1939–1943. Too much reliance cannot be laid on this figure, since Northern Irish experience may not be representative, but it is used in the absence of other information, and is unlikely to be far from the truth.

The calf mortality rate is computed from the following formula:

$$M_C = \frac{D_C}{B} \times 100,$$

where
M_C = calf mortality rate;
D_C = deaths of calves under one year old;
B = total number of live births occurring during the same time period.

If the calf mortality rate were to be computed as an age-specific rate it would be the ratio of calf deaths to the number of calves in the population exposed to the risk of death throughout the year. However, the average of the calf population as recorded at each census does not adequately measure the exposure to risk in view of the shortness of life of many calves—a number of which will never be recorded at a census. The mortality rate is thus taken as the ratio of calf deaths during a given year to the live births in the same period. These death rates are shown in Table 47 below; and the rates computed for deaths excluding the recorded slaughter are given for comparison.

TABLE 47—*Calf mortality rates*

Deaths under one year per 100 live births

	All deaths	"Natural deaths"
1940	43·8	16·8
1941	52·9	18·4
1942	53·0	17·7
1943	50·9	9·1
1944	50·6	7·6
1945	50·3	5·0

The table shows that apart from the year 1940 the calf mortality rate remains fairly constant at about 50 to 100 births. The rate for "natural deaths" falls from 18 per 100 births in 1941 to 5 per 100 births in 1945.

(2) *Birth and fertility rates*

(a) *Crude birth rates*

The crude birth rate is an overall measure of the reproduction of the cattle population. It is computed from the following formula:

$$R = \frac{B}{P} \times 100,$$

where
R = crude birth rate;
B = total live births in a given period;
P = total population.

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The crude birth rate is calculated over a period of twelve months. This is the most appropriate time period, as births of cattle are subject to marked seasonal variations. But as these variations are of considerable interest, the separate rate for each quarter has been computed, adjusted to an annual basis:

TABLE 48—*Crude birth rates*

Number of births per 100 population

	Annual basis	Quarterly basis			
		December–February	March–May	June–August	September–November
1940	37·9	33·2	45·2	33·2	40·0
1941	37·7	35·2	44·0	38·8	32·8
1942	38·1	35·2	46·4	35·6	34·4
1943	37·4	34·8	44·8	32·0	38·4
1944	37·2	37·6	41·2	32·8	36·8
1945	35·8	36·0	42·0	30·0	35·2

The crude birth rate has been defined as a "number that indicates the proportional contribution or addition made to the total population each year by live births."* This statement is, however, quite inappropriate for the cattle population. The disappearance of calves in the first year of life, whether intentional or otherwise, is so large that the level of the crude birth rate has little influence on the contribution made each year to the total population. It is thought, therefore, that a second rate could usefully be computed, of equal if not of greater interest than the first, the crude "surviving birth rate." This indicates the proportional contribution that live births are permitted to make to the total population. Data are available for the years 1938–1943 and the rates are as follows:

TABLE 49—*Calculation of crude "surviving birth rates" (thousands)*

	Number of "surviving births"	Averate total population	Number of "surviving births" per 100 population
1938	1,623	8,082	20·1
1939	1,514	8,136	18·6
1940	1,437	8,247	17·4
1941	1,470	8,157	18·0
1942	1,561	8,168	19·1
1943	1,524	8,372	18·2

(b) *Fertility rates.*

The fertility rate is simply a modification of the crude birth rate; it recognizes that the risk of bearing a calf is limited to certain sectors of the cattle population. Three separate populations are chosen as denominators, and each of the three rates so obtained has a different interpretation and interest in the population study.

It is computed from the following formula:

$$R = \frac{B}{P} \times 100,$$

where R = fertility rate;
B = total live births in a given year;
P = total female population exposed to risk:
(1) P_1 = total female population one year old and over.
(2) P_2 = total breeding cows and heifers;
(3) P_3 = cows and heifers in milk at end of the year.

The first rate compares births with the total average female population exposed to the risk of bearing calves. This is assumed to be all female cattle over the age of twelve months, whether

* *Vital Statistics Rates in the United States, 1900–1940.*

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in beef or dairy herds. The fertility rates calculated on this basis and shown in Table 50 below vary between 53 and 59 births per 100 population.

The second version of the fertility rate uses as the denominator the total of breeding cows and heifers. These female cattle are classified in the census under the two heads: cows and heifers in milk and in calf, and heifers in calf with first calf. The estimated figure of heifers in calf is used in the computation of these fertility rates (see Table 31). By definition these cows and heifers have either calved recently or are due to calve within nine months of the census date; it follows, therefore, that unless removed by death the great majority of these animals will calve in the succeeding twelve months. The table shows that the rate varies between 82 and 85 births per 100 breeding stock. This means that taking the average population over any annual period, roughly 84 calves can be expected for every 100 breeding cows and heifers.

TABLE 50—*Fertility rates*

(Methods I and II)

Number of births per 100 population

	Cows and heifers one year old and over	Breeding cows and heifers
1940	58·6	84·6
1941	57·1	84·6
1942	57·8	84·5
1943	56·4	82·4
1944	55·8	83·1
1945	53·5	81·2

The third variant of the fertility is a ratio of the number of births to the number of cows and heifers at the end of the year. This measures the performance of the calved cows and heifers which are returned at the December census. It is obvious that the rate will be close to 100, but will only, after very exceptional circumstances, equal or exceed it. For this to happen it would be necessary to experience heavy mortality amongst the new heifers after calving or a sudden change in practice by which cows at the end of the milking life were culled immediately *after* calving instead of towards the end of their final lactation. This third fertility rate is computed and reproduced here for the sake of completeness and to illustrate the statistical method. Little importance, however, can be attached to year-to-year changes in the rate shown below because the mortality incidence largely governing these has to be assumed in calculating the number of births. The details of the calculation are reproduced in Table 51 below, and on the basis of these figures the rate is seen to vary between 94 and 98 births per 100 population.

TABLE 51—*Calculation of fertility rates* (*thousands*)

(Method III)

	Estimated number of births	Cows in milk at end of year	Number of births per 100 population
1940	3,128	3,243	96·5
1941	3,077	3,138	98·1
1942	3,110	3,251	95·7
1943	3,133	3,315	94·5
1944	3,179	3,269	97·2
1945	3,073	3,230	95·1

(3) *Summary*

In conclusion, it is interesting to summarize the principal data discussed in the foregoing paragraphs, and this is done in Table 52 below. The most striking feature is the excess of deaths over births for the whole six-year period, despite the steadily rising population. This apparent inconsistency is, of course, explained by the imports of cattle from Ireland, which partially replace the calves which die in the first year of life.

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TABLE 52—*Summary of vital statistics (thousands)*

1940–1945

	Average total population	Estimated number of— Births	All deaths	Deaths under one year	Rate per 100 population Births	Deaths	• Calf mortality rate (per 100 births)
1940	8,247	3,128	3,488	1,370	37·9	42·3	43·8
1941	8,157	3,077	3,519	1,627	37·7	43·1	52·9
1942	8,168	3,110	3,277	1,647	38·1	40·1	53·0
1943	8,372	3,133	3,336	1,596	37·4	39·8	50·9
1944	8,556	3,179	3,497	1,609	37·2	40·9	50·6
1945	8,576	3,073	3,486	1,547	35·8	40·6	50·3

It is seen from the table that the deaths of calves account for nearly half the total, and as a result the population gains only 1·5 million home-reared young animals each year. As this inflow is insufficient to maintain the size of the population, store cattle and milk cows are brought in from Ireland. These number 570,000 in 1940 and 400,000 in 1945.

PART II.—A SURVEY OF SOME OF THE CHANGES IN OUTPUT, PRODUCTION METHODS AND CAPITAL STRUCTURE OBSERVED IN THE BEEF PRODUCING, MILK PRODUCING AND CATTLE REARING INDUSTRIES BETWEEN 1939 AND 1945

INTRODUCTION

In the second part of this enquiry it is proposed to study certain aspects of the three industries which between them are responsible for the eight million cattle in Great Britain. The discussion will be confined entirely to those changes in output, capital holdings and production processes directly influencing the cattle population; it will not, for instance, be concerned with changes in the supply of labour or in investment in new machinery. References will, of course, be made from time to time to the supply position of other factors of production the shortage of concentrated feeding-stuffs, for example—but it is not the purpose of this enquiry to provide a measure of war-time changes.

SECTION I.—THE BEEF PRODUCING INDUSTRY

The beef producing industry is concerned with the feeding of store cattle until they reach the required weight for slaughter. There are two exceptions to this practice; "baby beef" may be marketed at fifteen to eighteen months, or a "young beef" at eighteen to twenty-four months, thereby missing the store period.* This practice has been discouraged during the war, for the consumption of concentrated feeding-stuffs is very high in proportion to the quantity of meat produced. Throughout this discussion, which deals purely with the war years, it is assumed that the production of "baby beef" and "young beef" is discontinued.

It should further be noted that there are two distinct seasonal phases in the feeding and marketing of store cattle—Winter feeding in yards and Summer feeding on grass. In the Autumn, cattle are selected for fattening in stalls and yards, and it is usual to feed the roots, straw and concentrates accumulated from the previous harvest. The pre-war practice was to fatten one batch of animals before Christmas and to start a second batch in January to be marketed in the early Spring. The labour involved in yard feeding is obviously much greater than that required for Summer feeding, but the cost of this additional labour is believed to be largely offset by the value of the manure which is trodden in the yards and thus forming an important by-product. Some farmers are known to practise stall-feeding to convert straw and roots into farm-yard manure, even if the profit from the sale of the fat cattle is very small. The fattening of grass-fed animals, on the other hand, starts as soon as grass becomes available in the pastures and continues throughout the Summer. Little if any concentrates are fed during this period.

* Watson and More. *The Science and Practice of British Farming*, p. 521.

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(1) *The supply of raw materials*

The feeder of beef stores is dependent on supplies of two raw materials—supplies of store cattle and the feeding-stuffs with which to fatten them. This paper is not primarily interested in changes in the amount of concentrated and other feed available—a question which does not at any time permit of very precise measurement—but a few facts of common knowledge may be noted here.

To take the grass feeder first. The acreage of permanent pasture is drastically reduced after 1939—a step which immediately reduces the area of grazing available for fattening cattle. This tendency is, however, partially offset by two things, the greater use and better management of temporary pastures, and the greater production of green fodder crops. It is quite impossible to assess from the acreage figures the effective loss of feed—firstly because the acreage associated with cattle-feeding concerns cannot be separately distinguished, and secondly because better management can alter the relationship between acreage and the quantity of feed available. With a more detailed industrial classification of enterprises, valuable estimates could be obtained of changes in the quantity of home-grown feed available to the beef industry; but such an enquiry demands both advanced technical knowledge and field surveys. Estimates of this kind are therefore impossible for the economic statistician using the customary statistical series. The Winter feeder is affected to an even greater extent by war-time shortages. The animal feeding-stuffs rationing scheme deprives him of all purchased concentrates, with the result that only home-grown feeds are available. This causes a substantial change in feeding practice, as it is now necessary to substitute "roughages," straw, hay and roots, for much of the cereals and oilcake used before the war. Technical evidence indicates that such a change to less intensive feeding results in a slower rate of fattening.

The conclusion to be drawn from this brief survey is that the Summer feeder, though temporarily embarrassed by the ploughing-up directions, may easily adjust his arable practice to keep all, if not more, of his pre-war head of stock. The Winter feeder has more intractable problems. He can get no purchased concentrates, and his usage of home-grown oats or pulse is restricted by the County Committee. He must, therefore, feed a higher proportion of roughages and so contend with a slower rate of fattening.

The second category of raw material is the store cattle. In this study the beef industry is credited with new supplies of stores when they reach the age of two years; before that time they are presumed to be in the hands of the rearer. This is clearly an arbitrary line drawn for convenience in the analysis, but one which is believed to be justified. The feeder may acquire his stores a few months earlier, and, in effect, finish the rearing process on his own premises—or alternatively he may purchase "forward stores" which are older than two years. The aim of this analysis is to consider general trends within the industry as a whole, so that the activities of different feeders tend to cancel out. The beef industry draws its stores from two sources—from the rearer in Great Britain or from the rearer in Ireland. It has, moreover, a second choice in selecting its raw material, for stores may be either male or female.

In 1940 the beef industry obtains from all sources 1·36 million two-year-old stores, and of these, 446,000, or 33 per cent., are imported. In 1943 the stores available number only 1·06 million, but by 1945 recover to 1·12 million—an increase mainly attributable to improved supplies of heifer stores. An analysis of the annual totals is given in Table 53 below.

TABLE 53—*Estimated number of stores available to the beef industry* (*thousands*)

	Total	Home-bred		Imported	
		Steers	Heifers	Steers	Heifers
1940	1,362	505	411	289	157
1941	949	519	371	50	9
1942	1,077	420	289	267	101
1943	1,062	412	341	250	59
1944	1,115	413	410	242	50
1945	1,117	395	390	247	85

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In 1945, therefore, the purchase of stores for feeding is 1·12 million, 245,000, or 18 per cent., lower than in 1940. This change can be explained in two ways. It is possible that in 1945 the industry is reluctant to acquire the 1940 number on account of the scarcity of feeding-stuffs, but on the other hand it can be argued that the smaller intake is due simply to a shortage of stores coming forward from home-rearers and importers. A conclusive answer to a problem of this kind cannot be provided by statistical analysis alone; it requires the detailed knowledge of a market expert; nevertheless, it is interesting to set out the available evidence, and this is discussed below under three heads:

1. It must first be remembered that of the four sources of supply three are sensitive to short-period variations in market demand and the fourth is not—the number of home-bred *male* stores coming forward is dependent on the decision of rearers two years before. In 1939, as Table 36 shows, the number of steers reared for beef is the highest ever recorded—a fact which explains the large number available to the beef industry in 1941. But in 1940 and following years the number reared shows a heavy fall. This decision may have been influenced by the scarcity of suitable feed for the young calves, or rearers may have decided that the beef industry two years hence would require fewer stores; but whichever it is, the trend has shown no signs of being reversed up to 1945.

2. The second group of home-bred stores—the heifers—is affected by the increased demand for dairy stock. The competition for yearling heifers is particularly acute in 1942, when the milk industry takes at least 100,000 of the females originally reared for sale to the beef industry. However, by 1944 the numbers available for beef production equal the 1940 figure.

3. The imported male and female classes are both affected in 1941 by the outbreak of foot-and-mouth disease. Heifer imports, which number little over 50,000 in 1943 and 1944, are affected clearly by the demand for milk stock in Ireland; but it is not so clear why increased numbers of imported steers are not brought in to offset the poor supply of home-bred animals. In view of the shortage of home-bred stores, this would seem to be the obvious course for the beef industry to follow.

This evidence suggests two things: Firstly, the shortage of beef stores is undoubtedly acute in 1942 and 1943, three things contributing to this—the exclusion of Irish imports, the competition of the milk industry, and the effects of the changed policy of rearers two years before. Secondly, the shortage may well have eased in 1944 and 1945, as more home-bred heifers are available, and little attempt is made to restore imports to the 1940 level. Another factor supporting this view is the level of average store prices as recorded by the Ministry of Agriculture. These rise sharply between 1938 and 1943 and remain fairly constant in the next two years.

It has already been seen that the total number of stores purchased for beef production falls by 245,000 between 1940 and 1945. As this means a reduction of nearly one-fifth in total store purchases, it is interesting to obtain for comparison an estimate of the change in total cost to the industry. During this six-year period store prices rise to a marked degree, and with the aid of the index of store prices compiled by the Ministry of Agriculture it is possible to obtain a rough estimate of the total value of all stores purchased in the war years. In 1940 the value can be shown to be in the region of £25 million, rising to £29 million in 1945.

Stated as indices, with 1940 as the base year, changes in the numbers and the total value of store cattle are as follows:

TABLE 54—*Indices of changes in the number and value of stores purchased for beef production*

(1940 = 100)

	Number	Value
1940	100·0	100·0
1941	69·7	83·7
1942	79·1	101·6
1943	78·0	105·1
1944	81·9	114·5
1945	82·0	114·8

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It is clear from the figures that the fall in the quantity purchased of this raw material is more than counterbalanced by the increase in price, and as a result producers are investing annually between 14 and 15 per cent. more than in 1940.

(2) *Length of the production process*

Before the war the "period of keep" of a store animal was commonly believed to be about six months, that is to say, the store is taken over by the beef industry and subjected to an intensive six months feeding before being slaughtered for beef. No data are available to show whether this conventional time schedule was adhered to by all pre-war beef producers, but as the objective of the industry was the out-turn of small lean beasts of " prime quality," it seemed unlikely that there would be much deviation from the normal practice. Furthermore, it can be shown that beef from *imported* stores is being produced to this pattern in the early months of the war (Part I, p. 195). However, when these assumptions are tested with respect to home-bred animals it is found that they produce results quite inconsistent with the known facts. The pre-war position can only be ascertained by empirical means, but the results so obtained, if correct, show the assumption to be wrong in more than one respect. Firstly, it would appear that at the outbreak of war, the duration of the production process is not the same for all classes of animals; there is a difference of more than three months between the home-bred and imported classes. Secondly, the production process is not uniform in length for home-bred steers and heifers; the evidence suggests that the production of beef from steers takes about nine months, and from heifer stores about twelve months. There is nothing in the statistical evidence to suggest the reason for such a difference and, moreover, nothing has been found in technical literature bearing on this point.

However, as the war brings an acute shortage of the essential concentrated feeding-stuffs this production pattern is modified. The substitution of home-grown feeding-stuffs for concentrates does two things; it prolongs the production process and increases the demand for larger and heavier animals, probably because home-grown "roughages" and straw can be utilized more efficiently by such animals. A convenient method of ascertaining the length of the production process is readily available, for if a store is slaughtered at the age of three years, then the actual process of transforming the beast from a "store" to a "fat" weight occupies one year. This assumption of the two-year base line must, therefore, be kept in mind in interpreting the estimates that follow. In view of the different method of production, the figures for Winter and Summer beef output will be considered separately.

(a) *Winter beef production*

The change that takes place can be illustrated by comparing the average length of the production process for steers marketed in the Winters of 1941 and 1944 respectively.

TABLE 55—*Average time taken to Winter fatten home-bred and imported steers (months)*

Month of slaughter	Home-bred		Imported	
	1940–41	1944–45	1940–41	1944–45
November	9·2	11·7	6·1	10·0
December	10·0	12·0	6·5	11·0
January	10·2	12·1	6·1	11·0
February	10·5	13·0	5·7	11·2
March	11·0	13·5	5·6	11·1
April	10·8	13·0	6·0	8·9
May	10·7	12·8	6·1	8·3

It is clear from the table that by the second Winter of the war the time taken to produce a fat, home-bred steer is already above the nine months mentioned above, and that the following four years bring a further two months' increase. Beef production from imported stores, on the other hand, still retains the conventional "six month period of keep" in 1940/41, but shows a very marked increase by 1944/45.

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These figures have perhaps a greater significance than is apparent at first sight. By the Winter of 1944 the home-bred male store is retained for 12–14 months, as part of the short-period capital of the beef industry, the imported store for 8–11 months. This means two things: the specialist Winter beef producer takes a much older animal into his yards than hitherto, and thus makes the purchase not direct from the rearer of replacement beef stock, but from some other enterprise willing to maintain the stores during the previous Summer months; secondly, the production process, now lengthened by three or more months, is bound to fall into two phases, Summer grazing followed by yard fattening. Thus the statistical reasoning suggests that the longer production process makes necessary a new category of producers—producers willing to take over two-year-old stores from the rearers and to carry them on until such time as they are required for Winter beef production. This development is consistent with the assumption made earlier that older stores are preferred where the feed is largely roughage. It also partially explains the high price of stores purchased for Winter beef production, for this initial feeding process will only be undertaken for a suitable return. Material collected by the Midland Agricultural College in the Winter of 1944/45 supports this assumption.* The average value per head of the cattle procured for yard feeding exceeds £36. This compares with an average price of about £26 as recorded by the Ministry of Agriculture over the same period, and it is apparent that the value of beef stores may appreciate in the initial feeding period by as much as £10 per head.

(b) *Summer beef production*

Turning to Summer beef production the same tendency to prolong the feeding period is apparent. Figures parallel to those given in Table 56 are shown below.

TABLE 56—*Average time taken to Summer fatten home-bred and imported steers (months)*

Month of slaughter	Home-bred		Imported	
	1940	1945	1940	1945
June	10·1	13·0	6·4	9·0
July	10·2	13·3	7·0	9·0
August	10·7	13·0	7·1	9·1
September	10·4	13·1	6·9	9·7
October	9·3	12·7	6·4	9·4

The table shows that "Summer-fed" cattle are maintained throughout the Winter before entering the final phase of production. This may well prove to be an even more costly procedure than the preliminary Summer-grazing of yard-fed cattle; for unless the stores are to lose condition they must be adequately fed and housed until the Spring grass is available.

(3) *Changes in amount of work in progress*

The work in progress or short-period capital of the beef industry is largely represented by the store cattle aged two years and over in the hands of producers. A simple count gives a crude measure of the amount of work on hand at any time, but the changes recorded in this total figure give little indication of important variations in the stage of production. After examining the trend observed in the total it is proposed to discuss the other features which are revealed by this statistical analysis.

In June 1940, the beef industry is in possession of 1·21 million store cattle—a high figure, which is partially explained by the large production programme undertaken by rearers in 1938. However, this record level is not maintained in the succeeding eighteen months; due to the cessation of imports the number of animals held is only 1·06 million in June 1941, falling further to 970,000 by December. These changes between 1935 and 1946 are shown in Table 57 below.

Imports are resumed in the Autumn of 1941, and by June 1942, animals in the hands of producers number over one million. From this date the trend is upward, and in June 1945, store animals number 1·31 million—96,000 higher than in 1940—and the largest number ever held by the industry. The 1946 figure is 1·36 million.

* *Economics of Yard Cattle Feeding under War Conditions*, Midland Agricultural College Survey Studies, 1946.

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TABLE 57—*Number of stores held by beef industry between* 1935 *and* 1946 (*thousands*)

	Number at June	Index (1939 = 100)
1935	1,119	97·8
1936	1,109	96·9
1937	1,117	97·6
1938	1,099	96·1
1939	1,144	100·0
1940	1,214	106·2
1941	1,056	92·3
1942	1,085	94·8
1943	1,092	95·5
1944	1,189	103·8
1945	1,311	114·6
1946	1,357	118·6

Table 57 above shows that the short-period capital of the beef industry (measured in quantitative terms) increases by nearly 15 per cent. between 1939 and 1945; but despite this change war conditions result in a substantial decline in the number of fat cattle sold for beef. This curious result can only be explained by a more detailed analysis of the figures, and the first point requiring examination is the composition of the work in progress. An analysis is given below of home-bred and imported stores, classified according to the time spent in the beef industry.

TABLE 58—*Analysis of home-bred and imported stores by time spent in the beef industry* (*thousands*)

	June 1940	June 1945
Total	1,214	1,311
Under 3 months	400	316
Over 3 months and under 6	340	148
,, 6 ,, ,, ,, 9	249	303
,, 9 ,, ,, ,, 12	133	254
,, 12 ,, ,, ,, 15	92	178
,, 15 ,, ,, ,, 18	—	23
,, 18 ,, ,, ,, 21	—	89

The table shows that the longer production process fundamentally affects the composition of the work in progress. It is axiomatic that such a change must follow a lengthening of the period of production, but the table emphasizes the fact that in 1945 the industry is not only maintaining more stores, but a much higher proportion of older and heavier stores.

(4) *Analysis of output changes* 1939–1945

Three factors influence the output of fat cattle during the war years. One of these factors, the exclusion of Irish imports during an outbreak of foot-and-mouth disease, affects the output for a relatively short period, but the other two changes are of longer duration. These are the shortage of concentrated feeding-stuffs and the competitive position of the dairy industry.

One of the problems in assessing the quantitative effect of such developments is the absence of any pre-war data. Control starts in January 1940, and by that date the output pattern of the industry is already changed by the war; for instance, the production process is longer. A second factor complicating the analysis is the amount of work on hand in the first year of control. Due to the large production programme of rearers in 1938 beef producers have more raw material available than usual. This causes a rise in the amount of work on hand (measured in numbers)—a matter of considerable significance to producers faced on the one hand with an excellent potential market and on the other with a difficult feeding-stuffs problem. Whatever the decisions reached

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by producers on the future of their output policy, the facts show that output in 1940—represented by the number of animals sold—is higher than in any other war year. But unfortunately it cannot be compared with the output of 1938 and 1939, so it is not known whether such an increase is part of a long-term output programme, or a measure precipitated by the emergency. The changes in output are given in broad outline in Table 59 below.

TABLE 59—*Number of steers and heifers purchased for slaughter (thousands)*

	Total	Home-bred		Imported	
		Steers	Heifers	Steers	Heifers
1940	1,267	457	366	290	154
1941	1,034	438	339	186	71
1942	905	455	283	121	46
1943	915	393	250	217	55
1944	932	360	281	237	54
1945	986	361	335	243	47

The table shows that the 1940 output of 1·27 million animals is never equalled in any of the later war years. It is clear, also, that the exclusion of Irish stores has a marked effect on the output in 1942.

In the following paragraphs an attempt will be made to separate out the three war-time factors responsible for this fall in output, and to estimate their quantitative effects. It would be convenient if the four classes of animals distinguished above could be considered in turn, but such an analysis would be highly unrealistic, and would in all probability give misleading results, because the changes are interrelated. Despite the chronological precedence of the exclusion of Irish imports (February–October 1941) this feature of the war-time beef industry will be dealt with last, as its effects are relatively short-term. Of the three factors to be described the shortage of feeding-stuffs will be considered first, the competition of the dairy industry second, and finally the break in Irish imports.

(a) *Influence of the feeding-stuffs shortage*

It has already been seen that the shortage of cereals and other concentrated feeding-stuffs necessitates the substitution of home-grown bulky materials, such as straw and roots. As older stores are required, therefore, for the final stage of production, the length of the production process is immediately affected.

The average length of the production process before the outbreak of war is assumed to be six months for imported stores, nine months for home-bred steers and twelve months for home-bred heifers. It can be shown that these times have changed, and the output is recalculated assuming the same intake of stores and an estimated pre-war length of the production period, the results giving an estimate of "normal" or expected output. This applies a correction for two things: firstly the change in practice due to the use of home-grown feeding-stuffs, and secondly the tendency to hold animals whenever raw material shortages threaten to reduce the amount of work on hand below a certain level. The latter practice appears surprising until it is remembered that a certain balance must be maintained between the work on hand and the home-grown feeding-stuffs. If the industry is suddenly and unexpectedly deprived of a fraction of one raw material, the stores, the production programme immediately becomes out of balance; the producer is extremely reluctant to leave roots and hay unconsumed (with an attendant loss of farmyard manure), or to allow leys or pastures to deteriorate for lack of grazing. The evidence indicates that such a shortage induces producers to hold fat animals longer, possibly attaining higher carcase weight at the expense of quality. Under more competitive conditions producers would clearly be more reluctant to feed to these heavy weights, but under control the heavy carcase, although unpopular with the butcher, does not reduce the return to the farmer.

It is estimated that the lengthening of the production process alone has reduced the total 1940–1945 output by something like 443,000 animals. The loss of output appears to be most severe in 1940 and 1941, but it is still substantial in 1945.

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(b) *Influence of the campaign for increased milk production*

The decision to encourage milk production, if necessary at the expense of beef production, is made in the Autumn of 1940, but since the supply position cannot be adjusted immediately, the extra dairy heifers needed for investment are obtained from the female beef replacements. Because of the price incentive many beef heifers around the age of two years are diverted to milk production, thus reducing the amount of new raw material obtained by beef producers. Table 42 and the accompanying graph show the effects of this diversion. From 1942 onwards heifers which would normally have been purchased by the beef industry in the Winter quarter—December to February—are bulled by rearers for sale to milk producers; and this practice continues throughout the last three years of the war. The effect of these diversions on the output of fat cattle can be roughly measured, and it is estimated that the output has been reduced in total by over 430,000 animals over the four-year period 1942 to 1945. This estimate takes account of diversions from both home-bred and imported store heifers.

(c) *The cessation of imports February–October* 1941

This cessation of imports has two effects on the output of beef animals, one direct and the other indirect. The direct effect can be measured fairly easily, for if the loss of raw material resulting from the prohibition is assessed the modification to output can be computed. The secondary effect is the lengthening of the production process of the home-bred animals, and this has already been accounted for in section (a) above. It is only necessary therefore to assess the direct loss of output, and this is estimated at 311,000 animals over the two years 1941 and 1942.

(d) *Summary*

It is now possible to bring these estimates together and to compare the "normal output" with the actual war-time output. The estimates shown below assume simply that no war-time shortages develop in supplies of stores or concentrated feeding-stuffs and, as a corollary, the pre-war "period of keep" is unaltered. The comparison is as follows:

TABLE 60—*A comparison of "normal" and actual output of fat cattle* 1940–45 (*thousands*)

	"Normal output"	Actual output	Estimated loss
Total 1940–1945	7,227	6,039	1,188
1940	1,380	1,267	113
1941	1,245	1,034	211
1942	1,220	905	315
1943	1,106	915	191
1944	1,123	932	191
1945	1,153	986	167

Too much reliance cannot be laid on the year-to-year changes, as the factors described above affect the "timing" as well as the quantity of output achieved. However, the figures undoubtedly give a reliable general picture of output changes. The loss from all causes is further illustrated by the chart. It is seen here that the widest gap between the estimated sales and the actual sales occurs in 1942. In this year all the three factors are operating to reduce output, and it is not surprising therefore that sales reach their lowest level of the war, the loss being estimated at 315,000. In other years only two factors appear to directly affect output. The total loss of output for the six years 1940–1945 may be analysed as follows: 26 per cent. due to the 1941 cessation of imports; 37 per cent. due to diversion to milk production; and 37 per cent. the result of the longer production process.

But the chart shows a second important feature—the decline in the "normal output." Thus a fall in output, amounting to nearly 240,000, still occurs between 1940 and 1945, even when the effects of the war shortages are eliminated. This decline may be explained in part by the abnormal circumstances in 1940, but the smaller imports received from Ireland after that year (see Table 2) and the small number of male calves reared for beef both suggest a planned reduction in beef

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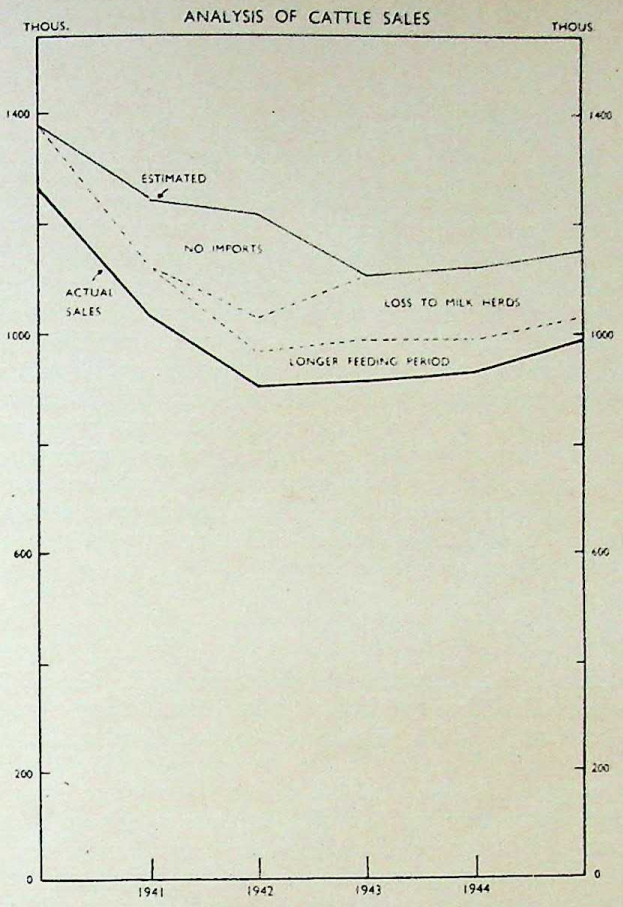

GRAPH 11

output. The pre-war sales of fat cattle can only be conjectured, but the census returns, showing the extent of the work on hand, suggest a figure of about 1·25 million head per annum—substantially higher than the computed "normal output" for the years 1941 to 1945. It may reasonably be concluded, therefore, that the three causes already examined are not solely responsible for the decline in output between 1940 and 1945; it is possible that the decline also reflects a smaller long-term production programme—a planned decline which war-time difficulties tended to accentuate.

(5) *Conclusions*

The main conclusions to be drawn from this study are as follows:

(1) The size of the beef industry (measured in terms of its short-period capital) increases by nearly 15 per cent. between 1939 and 1945; nevertheless war conditions result in a substantial decline—22 per cent.— in the number of fat cattle slaughtered for beef. (Tables 57 and 59)

(2) The production process has lengthened for all classes of stores; for home-bred and imported steers and home-bred heifers the increase is roughly four months. For imported heifers it is ten months. Owing to this change the industry is not only maintaining more stores in 1945, but a higher proportion of older and heavier stores. (Table 58)

(3) Three separate and measurable factors have influenced the output of fat cattle during the war years. It is estimated that the total loss is about 1·2 million head of cattle; and of

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this 26 per cent. can be attributed to the cessation of imports in 1941, 37 per cent. to the diversion of heifer stores to milk production, and 37 per cent. to the longer production process. (Table 60)

SECTION II—THE MILK PRODUCING INDUSTRY

The milk producing industry includes all enterprises owning milk cows and heifers that are producing milk for sale. Some integrated concerns owning what are usually known as "self contained herds" rear their own heifer calves, but for the purpose of this enquiry all replacement animals are considered part of the work in progress of the rearing industry.

The census total includes a number of cows not associated with the dairy industry; these are principally the beef cows and "household cows" producing milk for the farm household. A census of milk-selling cows taken by the Milk Marketing Board combined with the Scottish census of dairy cows allows an estimate to be made of milk cows owned by dairy enterprises in September 1942. At this date 2·7 million cows are estimated to be associated with the dairy industry—about 84 per cent. of the total. Thus one sixth of the cows in the country are maintained either for commercial breeding or for providing milk for domestic use—a significant ratio in considering sales of milk for human consumption. No later census has been taken, so the estimates cannot be brought up to date, but it is probable that the number of dairy cows changes in much the same way as the total number of cows. Between June 1939, and June 1940, the number of milk and breeding cows rises by 174,000, or nearly 6 per cent.

(1) *Length of life of capital units*

A cow may be considered as mature after the fourth lactation. Up to this time the yield is normally increasing—the yield of the first lactation being about 75 per cent. of the mature yield. In a healthy and well-managed herd the yield should be maintained until the eighth lactation or even longer.* It would be useful to know, therefore, the average time milk cows are retained in the herds, but this is not possible with the available data. The number of capital units above or below a certain herd age can be estimated, but the age at which they are finally discarded cannot at present be ascertained. Furthermore, in making these estimates it is not possible to separate out the beef cows. As beef cows may remain longer in the herds than the deep-milking dairy cows, it is reasonable to suppose that they will be more important in the higher age groups than in the lower ones.

A full analysis of the industry's stock of milk cows is only possible from December 1945, onwards. Details of the composition are given below for this date, June 1946, being added for comparison.

TABLE 61—*Analysis of capital units by time spent in the herd*

	December, 1945		June, 1946	
	Number (thousands)	Per cent.	Number (thousands)	Per cent.
Total	3,230	100·0	3,247	100·0
Under 1 year	738	22·8	760	23·4
1–2 years	656	20·3	651	20·1
2–3	590	18·3	597	18·4
3–4	512	15·9	576	17·7
4–5 „	364	11·3	368	11·3
5–6 „	348	10·8	281	8·7
6 „ and over	22	0·7	14	0·4

It is clear from the figures that the bulk of the milk cows owned by the industry are under four years old—in December 1945, 77 per cent. A further 22 per cent. are between four and six years old. This suggests that the wastage due to accident and disease is preventing the industry

* Watson and More, *The Science and Practice of British Farming*, p. 508.

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from benefiting to any extent from the biological yield factor; more than three-quarters of the capital units appear to be giving less than a maximum yield.

(2) *The influence of the milk campaign*

In the Autumn of 1940 the Government announced its intention of encouraging milk production, even at the expense of beef production. Prices were arranged to induce rearers to bull additional heifers—and to encourage new farmers to take up milk production. Two results of this campaign are discussed in detail below, firstly examining the effects on the receipts of new capital units by the industry, and secondly on the rate of wastage.

(a) *Investment in new producing units*

The decision to produce a milk heifer for the dairy industry is made at least nine months before the date of sale. It is therefore necessary to examine the statistics of heifers bulled, and Graph 10 shows the changes from December 1939, onwards. The high number observed between December 1939, and February 1940, suggests that an increase in the bulling of heifers occurs immediately the campaign opens, but in view of the heavy rearing in 1938 (and the consequent large number of cattle reaching maturity in 1940) it is very likely that the number bulled in this quarter would have been high, even had conditions been normal. Nevertheless, the peak is undoubtedly accentuated by the new development. But in 1941 the diversion of heifers from beef production is unmistakable; in the six months September 1941, to February 1942, only 68,000 heifers remain for sale to beef producers compared with 204,000 the year before (Table 42). The graph also illustrates this phenomenon: the large number of bulling heifers required in each Winter quarter seriously depletes the supplies of available beef animals. Using a graphical method, this diversion of heifers from beef production can be roughly measured, and estimates are given below of the actual and "normal" investment over the war years.

TABLE 62—*Estimated investment in milk heifers* (*thousands*)

	Actual investment	"Normal investment"	Diverted beef heifers
Total 1940–1945	4,414	3,857	557
1940	842	842	—
1941	615	615	—
1942	705	553	152
1943	740	626	114
1944	752	607	145
1945	760	614	146

If the number of "diverted heifers" is subtracted from the total actual investment a figure is available for "normal investment"—that is, the number of heifers that would have been acquired had there no special encouragement been given to milk producers. The "normal" level of investment at about 600,000 per annum is consistent with the pre-war size of the milk industry (measured in terms of the number of capital units), and the table suggests, therefore, that the level of investment observed in 1940 is anything up to 200,000 greater than usual. It must be emphasized that the analysis shown in Table 62 is very rough, but it indicates nevertheless that about 10–15 per cent. of the war-time investment in milk heifers is at the expense of beef production.

The heavy demand for milk heifers at the end of 1941 is also reflected in the average prices collected by the Ministry of Agriculture; the highest average price ever recorded is for the month of December 1941, when it reaches over £51 per head. This is an increase of 67 per cent. over the average price for December 1939. These average prices also permit a rough valuation of the investment in milk and breeding heifers between 1940 and 1945. It is estimated that £25 million are expended in 1940 compared with £32 million in 1945. Indices of numbers and value are given in Table 63 below.

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TABLE 63—*Indices of changes in quantity and value of investment in milk heifers,* 1940–1945

(1940 = 100)

	Quantity	Value
1940	100·0	100·0
1941	73·0	94·0
1942	83·7	120·5
1943	87·9	127·0
1944	89·3	126·4
1945	90·3	125·6

(b) *Wastage of capital units*

The number of beef and dairy cows on farms rises steadily between March 1942, and December 1943. But this expansion is not due entirely to the inflated investment described in the previous paragraph—the rate of wastage is also reduced. Part of the wastage is unavoidable; accident or acute illness may cause deaths on the farms. But three-quarters of the disposals are deliberately planned by herd owners—and as most of these cows are slaughtered for beef their numbers are known fairly accurately. Thus the inducement provided for increased milk production is liable to reduce, or at least delay disposals of this type, and the statistics show that this is in fact the case. The total annual wastage falls from 22·7 per cent. in 1941 to 18·6 per cent. in 1942 and 20·6 per cent. in 1943. The table shows furthermore that the changes observed are due entirely to the lower disposals for beef.

TABLE 64—*Wastage of beef and dairy cows (per cent.)*

	Total	Disposal for slaughter	"Natural causes"
1940	22·7	16·9	5·9
1941	22·6	16·5	6·0
1942	18·6	12·5	6·1
1943	20·6	13·9	6·7
1944	24·2	17·7	6·5
1945	24·6	18·5	6·1

The higher wastage rates in 1944 and 1945 suggest that some of the cows kept beyond the normal term may now be leaving the herds. This is resulting in a fall in the number of milk cows owned by the industry.

(3) *Summary and conclusions*

The main features of the dairy industry may be summarized as follows:

(*a*) It is only possible to distinguish the dairy and beef cows in September 1942. At this date it is estimated that 2·7 million cows are associated with the dairy industry, or about 84 per cent. of the total.

(*b*) Between 75 and 80 per cent. of the capital units held by dairy and breeding enterprises have been in the herds less than four years, and are thus giving less than the mature milk yield. (Table 61)

(*c*) The pre-war annual investment in dairy and beef cows is estimated at roughly 600,000 head. In 1940 the industry accepts about 200,000 more than this figure—a phenomenon mainly due to the heavy rearing programme undertaken by rearers in 1938.

(*d*) Between 1941 and 1945 investment rises from 615,000 to 760,000 head. This increase is made possible by the diversion of heifers from beef production. Over the six-year period it is estimated that the diverted heifers constitute between 10–15 per cent. of total investment. (Table 62)

(*e*) The number of capital units owned by the milk producing industry rises substantially as the result of the official campaign. This expansion is brought about by two changes—an increase in the rate of investment in milk heifers and a decrease in the rate of wastage. The fall in the rate of wastage is not being maintained; between 1943 and 1945 it rises from 20·6 per cent. to 24·6 per cent.

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Section III—The Cattle Rearing Industry

The cattle rearing industry comprises all enterprises producing replacement stock for the beef and dairy industries. It is responsible for all the young animals, calves, yearlings and heifers in calf, and for those mature breeding cattle, mostly beef cows and bulls, that are not associated with a dairy enterprise.

The number of young cattle—the work in progress—is known from the census returns, but the number of breeding stock can only be roughly ascertained. It is estimated that the industry has at its disposal about half a million beef cows and 30,000 beef bulls. The number of young stock rises by 218,000, or 6 per cent., between 1939 and 1945. (See also Table 30)

The rearing of calves is an enterprise which calls for a greater element of risk-taking than the two industries described previously. Two years must pass before a steer or heifer calf can be sold as a store, and about two and a half years before a heifer is available for the milk and breeding herds. Thus the rearer must anticipate future trends in demand for his various types of cattle, and must keep in mind the strong competition from Irish-bred cattle.

(1) *The supply of calves for rearing*

The cattle rearing industry obtains its raw material from the breeding stock maintained for the purpose and from calves available as a by-product of the dairy industry.

The total number of calves born each year is estimated at around 3·1 million, and of that figure possibly as many as 500,000 are available from the beef stock. Many of the remaining calves are uneconomical to rear, due to the use of unsuitable or "scrub" bulls, and these are normally killed within a few days of birth. Other calves, including those producing inferior mature animals, are fattened and marketed as veal. It follows, therefore, that the cattle rearing industry draws its young stock mainly from two sources—from its own specialized breeding stock and from dairy herds using a suitable bull. Imports are negligible.

In view of the interest taken in the question of expanding beef production in this country it is useful to compare the available raw material with the use made of it. The figures for 1940–1943, which are summarized below, reveal a surprising position; less than half of the calves born are acquired by the industry and reared as replacements.

Table 65—*Estimated disposal of calves available to the rearing industry*, 1940–1943 (*thousands*)

	Total calves born	Reared as replacements		
		Total	Male calves	Female calves
1940	3,128	1,437	447	990
1941	3,077	1,445	440	1,005
1942	3,110	1,539	449	1,090
1943	3,133	1,519	412	1,107

The table shows that the cattle rearing industry accepts around 1·5 million of the three million calves available in each year, and these are reared to meet the demand, twenty-four to thirty months hence, for store and new dairy stock. The remaining calves fall into two categories—those used for veal production, and those which are killed soon after birth or which die from natural causes. In 1940 and 1941 about 33 per cent. of the calves not required as replacement are slaughtered as veal; in addition a further 30 per cent. are slaughtered for food, though giving meat of an inferior quality. Due to the lower standard required by the Ministry of Food and the need to obtain the maximum amount of meat, the number sold both of "vealers" and of inferior quality calves rises considerably, these changes reducing the percentage of unmarketed calves from 40 per cent. in 1940 to 13 per cent. in 1945. These changes are illustrated by the figures in Table 66 below. The total annual wastage is little altered, but the number of unmarketed calves falls from 600,000 to 200,000. The increase in the number of calves slaughtered for food does not necessarily indicate a reduced rate of rearing—it may merely reflect a change in the manner of disposal.

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TABLE 66—*Analysis of estimated wastage of cattle under two years old* (*thousands*)

	Total	Sold for slaughter	Other deaths
1940	1,415	843	572
1941	1,672	1,061	611
1942	1,692	1,096	596
1943	1,642	1,311	331
1944	1,656	1,367	289
1945	1,595	1,394	201

It is interesting to consider the obstacles to greater use of the raw material available as a by-product of the dairy industry.

(*a*) In some dairy enterprises service is arranged with the sole purpose of getting the cow in milk. As a result of using a low-grade bull the calf may be quite unsuitable either for milk or beef-production. Such calves are usually disposed of immediately.

(*b*) At a very early age even strong and healthy calves are difficult to move, and lack of food and attention during the journey may have serious results (such as infection by white scour).

(*c*) The use of dairy bulls tends to produce calves which are inferior for beef production.

(*d*) The possibly inferior home-bred store has to compete with the high quality Irish import.

Despite these difficulties, there seems little *prima facie* reason why insufficient suitable calves should not be available to meet all requirements. Only about 800,000 heifer calves are required each year for breeding, requiring possibly 1·6 million calvings—that is, if one out of every two calves born is assumed to be female (see Table 36). An appropriate solution would be the up-grading of the bulls used on many small and non-self-contained herds to provide dairy-beef crosses of good quality. This would mean that dairy herds (not self-contained) would continue to invest in specialized dairy stock as replacements are needed and, using a beef bull, would dispose of their beef-crosses to the rearing industry.

The number of cows and heifers served is about 3·1 million a year. Thus if 1·6 million services are arranged with dairy bulls, 800,000 heifers are available as dairy replacements and the male calves can be used for veal. The remaining 1·5 million services should then be with beef bull; and this will include the 500,000 specialist beef cows. Thus rearers of beef stock will have the choice of calves from the half million specialist beef stock plus those from about one million dairy-beef crosess. This is twice the number normally accepted by the industry (see Table 39), and should provide ample reserves for any degree of expansion.

TABLE 67—*Suggested breeding plan* (*thousands*)

	Number of services	Calves available		
		For milk	For beef	Surplus
Total	3,100	800	1,500	800
Using dairy bulls	1,600	800	—	800
Using beef bulls	1,500	—	1,500	—

But such an arrangement will clearly depend firstly on sufficient beef bulls being available, secondly on the co-operation of many (non-self contained) dairy herds, and above all on the efficient and economical movement of young calves from the birth-place to the rearing enterprise.

(2) *Changes in the output of young stock*

Since the cattle rearer must hold his animals for two years or over before sale as mature stores or breeding stock, it is clear that a high total output in any year reflects a state of confidence two years before. The practice of the rearer is largely governed by biological factors, for his partly finished work cannot be put into stock awaiting the better market conditions.

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As already explained, one element of flexibility is very important—the possible diversion of dairy-type yearlings to beef production and *vice versa*. Thus, as the two female groups are to a certain extent interchangeable, the outflow of beef and breeding heifers can give little indication of the original expectations of rearers. One group, however, the steer calves, gives a useful indication of expectation regarding the beef market; for instance, the high level of output in 1940 and 1941 reflects the number accepted for rearing in 1938 and 1939. When the quarterly figures are examined it is seen that the rate of rearing is maintained until the Winter quarter of 1940. (See also Table 12)

The index number of prices published by the Ministry of Agriculture (base 1927–29 = 100) shows a twelve point increase for cattle between 1936 and 1938, and a fifteen point increase for milk. The abnormally high rate of investment undertaken by rearers in 1938 is thus consistent with this part of the evidence. Whatever the explanation, these collective decisions of rearers mean a high total output in 1940. The table below shows an analysis of the industry's output in 1940 and in succeeding years.

TABLE 68—*Estimated total output of the rearing industry*, 1940–1945 (*thousands*)

	Total	Mature cattle		Bull calves
		Store cattle	Milk heifers	
1940	1,681	863	779	39
1941	1,538	887	609	42
1942	1,392	680	662	50
1943	1,475	721	712	42
1944	1,564	800	728	36
1945	1,519	750	738	31

The estimates show that the output of the industry reaches its lowest level in 1942, but recovers gradually after that date; and further, that the number of store cattle sold always exceeds the output of milk heifers. It is worth noting that this output represents 97 per cent. of the requirements of the dairy industry, but only 70 per cent. of the requirements of the beef industry.

A rough valuation of the output can be made, using the index prices published by the Ministry of Agriculture.

TABLE 69—*Indices of changes in the quantity and value of output of the rearing industry*

(1940 = 100)

	Quantity		Value	
	Beef stores	Milk heifers	Beef stores	Milk heifers
1940	100·0	100·0	100·0	100·0
1941	102·8	80·2	123·9	102·8
1942	78·8	84·3	101·5	121·3
1943	83·5	92·3	112·6	133·5
1944	92·7	94·5	130·3	133·7
1945	86·9	95·6	122·1	133·1

The table shows that in both branches of the rearing industry the estimated value of sales increases substantially between 1940 and 1945, but it is worth noticing also that receipts from the sale of milking heifers increase by 33 per cent., and receipts from the sale of beef stores by only 22 per cent. The estimated total gross receipts of the rearing industry from the sale of mature cattle (excluding bulls) rises from roughly £39 million to £50 million, an increase of nearly 30 per cent.

(3) *The rate of wastage*

In a study of wastage it is essential to distinguish between (*a*) the disappearance of unwanted calves and (*b*) the loss of valuable animals through accident, illness or unthriftiness. Clearly only the latter represents an economic loss to rearing industry, for the unwanted calves in dairy

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herds may never leave the farm, and those sold as veal represent a secondary form of output. The number of calves sold may be ascertained from the available statistics, but the group is too heterogeneous to allow definite conclusions to be drawn regarding the rate of wastage. The statistics relating to calf sales include the calves specially fed for veal production, but also any animal, unwanted or unthrifty, which the farmer can get to the slaughte-rhouse. Thus those calves which die *after* being selected for rearing are found in both the slaughter and the "natural death" categories.

The results of a number of direct enquiries suggest that the mortality of calves selected for rearing may be as high as 10 per cent.* If this proportion is used to estimate the number of accidental deaths in each year, then the disposal of unwanted calves (whether on the farm or at the slaughter-house) can be obtained by difference.

TABLE 70—*Estimated wastage of calves* (*thousands*)

	Total	Slaughter of calves		Deaths due to accident or illness*
		For veal	Calves not required for rearing	
1940	1,370	461	742	167
1941	1,627	551	918	158
1942	1,647	556	926	165
1943	1,596	694	737	165
1944	1,609	747	695	167
1945	1,547	735	649	163

* Estimated at 10 per cent. of population under one year old.

It must be realized that the estimates in Table 70 above are extremely rough; they are intended only to give an order of magnitude. Nevertheless the figures are of interest because the calves not required for rearing, whether surplus animals of good quality or of an inferior type, represent the reservoir on which an expanding industry would have to draw.

(4) *Summary and conclusions*

The main features of the rearing industry may be summarized as follows:

(*a*) The size of the industry (measured in terms of the amount of work in progress) increases between 1939 and 1945 by about 6 per cent. (Table 30)

(*b*) The total quantity of output of mature cattle decreases by nearly 10 per cent., but it is estimated that the value of output increases by roughly 30 per cent. This excludes the sales of bull calves as an average price per head is not available. (Tables 68 and 69)

(*c*) Slightly more than half the output consists of store cattle—measured in numbers—but it is estimated that the gross receipts from the sale of milk heifers are 50 per cent. higher than those from the sale of store cattle.

(*d*) The industry accepts for rearing about 1·5 million of the three million calves born each year in Great Britain.

(*e*) The two branches of the rearing industry hold a very different share of the home market. In 1945 about 97 per cent. of the milk heifers sold to the dairy industry are home-reared, but only about 70 per cent. of the store cattle.

DISCUSSION ON MISS MARLEY'S PAPER

Dr. C. OSWALD GEORGE: It gives me very great pleasure to move a vote of thanks to Miss Marley for what is one of the most outstanding papers on this subject that we have had for a long time. In addition we must congratulate her on winning the Frances Wood Prize.

On occasions like this it is usual nowadays to apologize for not having properly studied the paper owing to lack of time, but never, I think, has such an apology been so excusable as on this occasion. We have before us a paper of 30 galleys with 70 tables and 11 graphs, and it is obvious that really to understand the Paper would require a great deal of time; to be able to criticize it very much more time; while to be able to judge its real value would require immeasurably more

* *Agricultural Output of England and Wales*, 1930–31, p. 17. *Agricultural Output of Scotland*, 1930, Table 10.

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time than I have at present. I am afraid, therefore, I shall have to restrict myself to one or two comments and questions.

Owing to special circumstances, Miss Marley, at very short notice, had to try to cut down her original and much longer paper, and to rush it through the press, and it has had to go through without any of the usual checks. Therefore it will be understood that any slight slips that have crept in, in the headings of tables and columns and so on, are due to the haste with which the whole thing had to be done.

Taking a general view of the paper, the first thing that strikes one is that it is a bold and lofty logical structure, and the first doubts that arise are not about the structure itself, but about the foundations. Are they strong enough to bear the high-powered logical argument which has been placed upon them? To cast any doubt in this direction is not to criticize the official agricultural statistics. These statistics are designed to provide figures with an accuracy sufficient for practical needs, and not to serve as a basis for lengthy chains of reasoning based on marginal differences. Criticisms have been made of agricultural statistics, but usually because they are too detailed, and perhaps over-accurate for their avowed purpose. Sometimes these criticisms have come from people who do not realize the practical difficulties involved in devising any satisfactory sampling substitutes.

Further doubts are caused by some of the assumptions made. For example, while the cycle of lactation is assumed to be 13 months, Miss Marley suggests that lactation lasts for 10½ months and the dry period for from 6 to 8 weeks, making in all 12 to 12½ months. Without wishing to be hypercritical, it does seem that small factors such as half a month or a month may make a substantial difference to the results. Another assumption is that the ages of cattle in the agricultural statistics are correct, but it has been alleged that in many cases the "yearlings" may be only 10½ months old, and a difference of a month or 1½ months here may have a substantial effect later on. Then take the case of the "springers" from Ireland. It is assumed that a springer from Ireland will immediately drop a calf, but it has been alleged that not more than 10 or 20 per cent. of these springers are actually in calf when they get here. If all these possible divergencies are in one direction, the effect on the conclusions may clearly be very substantial. Doubts also arise about the assumed proportions of males and females in Eire stores, which lead to strange results later on.

Then there is the implicit assumption that the quarterly figures (other than those for June) are as reliable as the June figures, and I was surprised, in a Paper dealing with quarterly variations, to find no mention of the fact that these other-than-June figures are based on estimates, and estimates in which the margin of error cannot easily be calculated owing to the way in which the samples are taken. This may not affect the main trends, but it may affect the alleged seasonal variations.

So one comes to the main body of the paper having these doubts at the back of one's mind, and one must hesitate before giving an opinion on a Table such as Table 31, which shows that in 1940 the difference between the number of heifers in calf in the official returns and the number calculated by Miss Marley was 2,000; in the following year the difference came to 96,000 and after that it ranged around 180,000. Naturally the professional statistician looks at these things rather differently from the academic statistician. He works on a lower level and, being rather puzzled by divergencies of this sort, he begins to look around for some explanation. I did so in the short time at my disposal and tried to tie up some of the figures of calves and heifers and bullings, but I was stuck at various points with substantial differences that I could not explain. Had I had the opportunity of discussing them with Miss Marley I might have cleared them up, but one of the difficulties in checking calculations of this sort is that periodically one comes up against the term "estimate," and unless one has the time to start the whole calculation over again or is aware of the basis of the "estimate," it is rather difficult to resolve any differences which arise.

Differences ranging from 2,000 to the rather substantial figure of 180,000 clearly call for investigation. One possible explanation is that some of the assumptions mentioned may not accord with the facts. Again, it is not clear how Miss Marley dealt with the cows which were dried-off. Did she assume that they were immediately slaughtered, or has she allowed for the fact that they might come into the over 2-year-old class? Any serious errors here might have a substantial effect on many of the Tables.

I was particularly intrigued by Table 7, which gives the average ages at slaughter of imported Eire stores. The December 1941, figure of 35·5 months, which is much higher than any neighbouring figure, immediately attracted my attention, and I thought it worth while to try to see how it was arrived at. Miss Marley has given us a very simple equation on p. 196 with which none of us should be puzzled. We are told to take X as the number at a given census, add on the number of Eire imports during the next quarter, and deduct the number of Eire animals

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slaughtered, in order to get the number of stores at the next census. This did not seem to be difficult and I tried it. I took figures from Table 3 showing the imports of store cattle from Eire, and Table 5 showing the number of imported stores purchased for slaughter, and checked the result with Table 6 showing the estimated number of imported stores on farms in Great Britain.

I got along admirably from 1939 to 1942, but when it came to the last three-quarters of 1943 I found at the end of each quarter that I was short, on the average, of 13,000 cattle. I went on further to 1944 and the first quarter of 1945 and found a shortage there of 3,000 cattle on the average per quarter, but then I again got into smooth water and found the figures were exactly as I had calculated them. I thought it was strange that this equation worked in some quarters and not in others; strange though it may seem, I preferred the occasions when the equation did not work, for the equation makes no allowance for deaths, and we can hardly expect that none of the Eire cattle imported into this country will die. On the other hand, the difference between the two sets of figures for the last three quarters of 1943, namely, 13,000 a quarter, seems excessive. This is at the rate of 52,000 a year, which would, I imagine, almost ruin the farmers concerned. It is all rather puzzling, and I still do not quite see whether there is something wrong with my calculations or with the figures in the paper.

I should like before I conclude to refer briefly to the conclusions reached by Miss Marley at the end of the Paper. In Part III, Section I, she sets out three conclusions. The first is that the size of the beef industry, measured in terms of its short period capital, increased by nearly 15 per cent. between 1939 and 1945, while there was a fall of 22 per cent. in the number of fat cattle slaughtered for beef. There can be no objection to the figures, which can be checked with the official statistics, but what needs a little clearing up is the use of the expression "in terms of its short period capital." Is it not misleading to refer to what is merely an increase in numbers as an increase in short-term capital?

Her second conclusion declares that the production process has been increased by four months in the case of home-bred and imported steers and home-bred heifers, and by 10 months in the case of imported heifers, but here, I think, we should like to know more about the various assumptions on which this is based.

The third conclusion is that there has been a loss of something like 1·2 million head of cattle, of which 26 per cent. is attributed to the stoppage of imports in 1941, 37 per cent. to the diversion of heifers to milk production, and 37 per cent. to the longer productive process—as estimated. I think one has to regard this also with some caution, because there was not only a complete stoppage during 1941, but also a reduction in the number of Eire steers in later years. To refer to 37 per cent. as a diversion to the milk-producing industry needs to be read in the light of the fact that a million and a half calves are killed each year.

The main features of the dairy industry are dealt with in the conclusions at the end of Section II. In conclusion (*a*) we are told that it is possible to distinguish the dairy and beef cows only in September 1942, when the Milk Marketing Board took their census; it might be well, in view of popular misapprehensions on the subject, to make clear that there are substantial differences, changing through the years, between the quantity of milk sold through the Milk Marketing Board, the total quantity of milk sold, and total milk production. In conclusion (*b*), it is stated that between 75 and 80 per cent. of the capital units held by dairy and breeding enterprises have been in the herds less than four years, and are thus giving less than the mature milk yield. This again depends on some of the assumptions mentioned earlier, and about which I have expressed doubts; and, incidentally, "capital units" are not "units" of capital. Conclusions (*c*), (*d*) and (*e*) call for little comment apart from the dubious use of economic terms.

Passing to the conclusions to Section III (p. 244), we find a reference to a 6 per cent. increase between 1939 and 1945 "measured in terms of the amount of the work in progress." The term "short-term capital" has disappeared and now we get "work in progress." This tendency to apply particular economic terms to cattle breeding seems to have little to commend it. In this particular case, to apply the term "work in progress"—which is usually measured in monetary values—to an aggregate of varying types and ages of cattle may be definitely misleading. Recently, a weekly periodical similarly showed that the output of cattle and calves in this country has increased to a higher level than before the war by the simple process of graphing the combined total of cattle and calves, but this type of aggregation is not to be recommended. Conclusions (*b*), (*c*) and (*d*) call for little comment.

In conclusion (*e*) it is stated that in 1945 about 97 per cent. of the milk heifers sold to the dairy industry were home-reared, but only about 70 per cent. of the store cattle. How many of these cattle were actually sold nobody knows, but there seems to be an implication here that there are three industries, beef-producing, milk-producing, and cattle-rearing, which are separate and distinct, but this hardly accords with the facts.

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There are many other points with which I should like to deal, but time does not permit. Let me conclude by saying that these few comments I have made do not in any way detract from my admiration for the work which Miss Marley has put into this paper. She has done a great work for agriculture. The official agricultural statisticians are too busy to undertake a task of this sort, but it is highly desirable that the task should be tackled, and we should all be glad that Miss Marley has had the time and ability to write a paper of this character.

Professor J. H. JONES: It is impossible, in dealing with agricultural problems, to secure such complete, well-defined and accurate statistics as those that are supplied, for example, by the Board of Trade. Nevertheless, I feel that we have received to-day a paper which is of outstanding importance. As I read it I was reminded of a book that I read some years ago on the economics of milk supply. The author of that book was also a lady; it is interesting that two of the outstanding contributions to agricultural economics in recent years have been by women.

I do not feel competent to discuss the details of the paper, and I shall only venture to submit two observations, both of a more or less practical character.

One of the main points brought out in the paper is that the age of slaughtering has been raised since 1938, and that that change raises an interesting question of economic policy. It seems to me, as a layman, that the policy of the Ministry of Agriculture or of the Ministry of Food—I do not know which—was of a highly debatable character. The purpose of raising the age of slaughter was to economize foodstuffs in the wider sense. But the rise in the age of slaughter meant that the cows had to be fed for a longer period. This itself involved a heavy consumption of foodstuffs. While the amount of the product was reduced its quality deteriorated and waste in meat consumption was increased. It seems to me that it would have been a wiser economy on the part of the Government to have aimed at a more rapid turnover, to have spent a little more on imported foodstuffs and to have slaughtered the animals at an earlier age, thereby preventing the law of diminishing returns from operating so strongly and people being compelled to attempt to eat tough beef.

My second point is not on the paper itself, but it seems to me to follow from it. Many years ago I was a member of a Government committee appointed to investigate the industry concerned with the slaughtering of animals. The committee was faced with certain facts that are relevant to the policy that we ought to pursue in the future. It was found that about half the meat consumed in this country was imported, the other half being produced at home. The best hides were those produced within the country, but they were not of sufficient number to meet all the requirements for Class "A" hides in the various industries. It was necessary to import from abroad the large remainder needed of that class. While a proportion of British hides were of Class "A," the bulk were below that class and therefore a source of loss to the community.

In this country the organization of slaughtering was probably the most unsatisfactory in the modern world. It not only failed to meet the requirements of humane slaughtering, but was very uneconomic. In the process of slaughtering we missed most of the opportunities for recovering by-products. Slaughtering was carried on in hundreds of establishments. There were about 200 municipal slaughter-houses, but practically all operated at a loss and all were behind the times. In none of those slaughter-houses was a serious attempt made to obtain all the by-products, with the result that the home-produced meat industry of this country was a disgrace in comparison with that of the United States and other parts of the world.

One of the ways in which we may be compelled to achieve and maintain a balance of exports and imports is by reducing our imports. Some of these are such as can be produced at home with very little change in our economic system. There is nothing in the nature of things that would prevent us from building up an animal industry very much more efficient than the one we have been accustomed to maintain in the past, and to link up that industry with the slaughtering industry in such a way as to produce a profound effect upon the importation of meat and cattle from abroad without introducing anything in the nature of artificial protection.

I have submitted these two related points for this reason: not only was the economy that we pursued during the war of a very doubtful character, but so long as we continue to pursue it, so long, that is, as we are content with the rise in the age at which animals are slaughtered, so long, too, shall we prevent the possibility of reorganizing the slaughtering industry, and thereby achieving a substantial improvement in the general economy of the nation. I feel that the reader of the paper has not only made an important contribution to our knowledge of the industry with which she was concerned, but also reopened the door leading to a highly necessary study of a neighbouring industry, namely, the slaughtering of animals and the supply of home produced meat.

I have therefore very great pleasure in seconding the vote of thanks.

The vote of thanks was put to the meeting and carried unanimously.

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Professor BRADFORD HILL said that the greater part of Miss Marley's paper lay outside his own "universe of discourse," but there was one point at which it overlapped—in the vital statistics she gave. Just before the war he had collaborated with Dr. Reginald Lovell of the Research Institute in Animal Pathology, of the Royal Veterinary College, in an investigation of the mortality rate of calves, both pre- and post-natal (*Journal of Dairy Research*, 1940, xi, 225). He could, therefore, add a few, and he believed reliable, figures to Miss Marley's rates of "infant mortality" and some measure of the pre-natal losses.

At the time of their enquiry, which related to the years 1936 and 1937, there was very little information regarding the magnitude of those losses as borne by the dairy industry. Figures from a part of Scotland had shown that they might be very heavy and a problem of much importance. Their inquiry was made mainly through the Milk Recording Societies, and particulars were secured for 335 herds. These herds were spread throughout England and Wales, and geographically appeared to have been a reasonably good sample of the total cow population. In dealing, almost entirely, but for practical reasons necessarily, with milk-recording herds it was evident, however, that they were surveying a selected class in which a relatively high standard of farm management would probably be the rule. The losses they recorded would, in that event, give a minimum rate. For those 335 herds, with an average size of about 40 cattle, there were reported in the two years some 25,000 live births. Of that total 1,251, or approximately one in 20, died before the age of six months—the age to which their observations of "infant mortality" extended. Contrary to human experience the death rate of females, 5·5 per cent., was higher than that of males, 4·4 per cent., but this was undoubtedly merely artificial. It was due to the disposal of bull calves very early in life so that their births were recorded but not all their deaths. Indeed, in the first week of life the male rate was 26 per cent. above the female rate, and in the human population the excess in 1936–38 was 28 per cent. It was in later weeks with the disposal of bull calves that the male rate became artificially low. For the whole six months the female rate of 5·5 per cent. was, therefore, the more reliable index of the level of infant mortality in calves.

They also had information on the incidence of stillbirths and abortions. Stillbirths numbered 4·7 per cent. of the total births (live + still). This was a figure that was not materially different from the 4 per cent. customary at that date in the human population of England and Wales. Of the total number of pregnancies recorded 5·5 per cent. terminated in an abortion. Here they could make no comparison with human events. Bringing these three forms of loss together they calculated that of nearly 28,000 pregnancies, approximately 15 per cent., or roughly 1 in 7, failed to produce a calf that survived to the age of 6 months—a quite substantial loss. There was, naturally, great variation round this average rate, but they did not find that geographical location played much part, though there was a slight increase as one went northwards and a higher rate in Scotland (their observations there were limited).

The smallest herds, on the whole, suffered the highest mortality, but generally the differences between different sizes of herd were not appreciable. Relation of the observed calf mortality to methods of husbandry did not suggest that three main methods of feeding had any material effect (suckling, bucket fed with undiluted milk, and bucket fed with diluted milk), nor did they show that the giving or withholding of water to drink was influential. There did appear to be some advantage in allowing the calf to take the colostrum naturally from its mother—an observation in keeping with experimental evidence that in that way there might be some transmission of immunity from the mother. There was some seasonal swing in the infant mortality rate which had its peak in the first quarter of the year and its lowest level in the third; stillbirths and abortions were not affected. Early post-natal life was, as one would expect, the most critical period, and nearly half the deaths took place in the first week and three-quarters in the first month of life.

Those figures, admittedly over a limited range of life and from a somewhat select population, presented, he thought, a little of the exact vital-statistical data that Miss Marley had sought. They also put on a numerical basis what was clearly an important problem in veterinary preventive medicine.

Mr. G. R. WHITE said that the author had made certain calculations regarding the age distribution of slaughtered animals. The basic assumption was that the animals slaughtered came from the higher age-groups. That seemed a reasonable assumption for any particular farm or perhaps for any particular district, but he doubted whether, if the figures for individual farms and districts were aggregated, the result would be the same. If not, it would affect the quarterly figures of the average age at slaughter.

Dr. George had already referred to Table 7, which gave the estimated average age of imported cattle at slaughter. This showed an increase of 7·3 months between December 1939, and December 1945. In Table 16, giving the figures for home-bred stores on farms, there was an increase of

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3·7 months between December 1940 and December 1945. The author had said elsewhere that one of the two main reasons for the lengthening of the production period was the use of homegrown foodstuffs. If it took longer to produce the same result by using homegrown foodstuffs, and the animal at the end was very much the same in both cases, one would expect to have approximately the same type of hide, but the author stated that owing to the lengthening of the production process for all classes of stores the industry was not only maintaining more stores in 1945, but a higher proportion of older and heavier stores. It would be interesting to find out whether in fact these heavier stores when slaughtered did yield heavier hides. He had had the figures for the average weight of ox and heifer hides taken out for the month of December from 1939 to 1946, in order to compare the same month in different years. The results showed that between December 1939 and December 1945 (the period covered by the Table for imported cattle), there was actually a decrease of 1·1 lb. per hide, that is to say, from 65·2 to 64·1 lb. Between December, 1940 and December 1945 (the period appropriate for home bred cattle), there was an almost negligible increase of 0·1 lb., namely, from 64·0 to 64·1 lb.

A phenomenon which had interested him very much from the hide angle, and for which he had been unable to discover any explanation, was the peculiar behaviour in June of the proportion of ox and heifer hides to total hides, which should reflect the proportion of oxen and heifers slaughtered to total cattle. He had taken monthly averages for the last three years. Starting in January, on the average 40 per cent. of the total hides were ox and heifer hides. That figure increased steadily through 47, 53 and 61 per cent. in subsequent months to 64 per cent. in May. Then there was a sudden drop in June to 53 per cent. In July it went back again almost to where it had been before, namely, 63 per cent., and then, after remaining fairly steady (65 per cent. in August and 66 per cent. in September), it started to drop again, and in the last months of the year, October, November and December, it was 59, 61 and 45 per cent. respectively. He had been unable to find any explanation of the reason why in the one month (June) in the middle of the year there should be so many cows slaughtered as compared with oxen and heifers.

He wished to endorse everything Professor Jones had said about the desirability of improving the raw material, and would point out that the reason why hides were deficient was two-fold. They might be below Class A for two reasons. One was that they were so badly cut when taken off the animal as to reduce their value; the other was that they might contain a lot of small holes due to warble fly. The way to obtain improvement was different in the two cases. In the one it was a matter of educating the slaughterers, and a great deal had been done in that direction; in the other, it was a matter of educating the Ministry of Agriculture. A campaign took place before the war which resulted in the Ministry of Agriculture passing an Order making it compulsory to "dress" all cattle against the ravages of the warble fly. This dressing was beginning to have beneficial effects when the war came; the Order was rescinded, and so far had not been reimposed.

He concluded by complimenting the author upon a monumental piece of work.

Mr. J. H. SMITH said that he had been most interested in the paper, which was, he supposed, a statistician's interpretation of what farmers had been doing in the cattle industry. He was not sure, however, whether the average farmer, if he could interpret the paper, would see his actions just as the author had seen them. He was specially interested in those parts of the paper dealing with dairy and breeding herds. The author calculated her intake of heifers by reference to statistics of cattle slaughter plus her estimate of natural deaths. There were two reasons why this estimate was likely to be too low. She ignored, in the first place, black-market transactions. He did not know the dimensions of these transactions, but it might be that they were sufficiently important to require recognition. Again, her method of calculating the natural death-rate would give her a natural death-rate for cows which was too low.

He was concerned with the estimates of intake into dairy and breeding herds. When Miss Marley's quarterly estimates of heifer calvings were tied up with the quarterly returns of in-calf heifers some interesting differences were revealed. Assuming that the heifers in calf, as shown in the quarterly returns, were to calve down over a period of nine months after the date of recording, then these calvings should approximate to Miss Marley's estimate over the same period. In March 1940 the quarterly returns showed 645,000 heifers in calf. The author gave the figure of 668,000 for heifer calvings during nine months following that date, or 4 per cent. more than the farmers stated were actually in calf. This discrepancy was not important. But the quarterly returns for September 1941 showed an estimate of 622,000 heifers in calf which would calve down during the following nine months. But the author's estimate of heifer calvings is only 347,000, or 56 per cent. of the recorded number. On the face of it that discrepancy did suggest that there was something wrong, and over the whole range of estimates there were discrepancies of the order of from 10 to 30 per cent.

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He would suggest two possible causes for the errors in the author's estimates. He had already suggested that the element of wastage—slaughter and natural deaths—was too low. Secondly, he had failed to find anywhere in the paper mention of the fattening period of cows, and could only assume that the author had failed to appreciate that cows are replaced in dairy and breeding herds some 2 to 4 months before the date of their sale as fat animals. If full account had been taken of this fact, the quarterly pattern of heifer calvings would have been quite different from that given in the paper.

That brought him to another important error in this paper based upon the same misunderstanding. Cattle feeders would be very much surprised to learn that the length of the fattening period for home-bred cattle was as long as that shown in Table 16 and, in particular, they would rightly question the author's estimate of the age of heifers at slaughter. The author had assumed that all female store cattle over two years were maiden heifers, while in fact the category included cows being fattened. It was not known how many cows are included in this category, but it might be anything from one-third to one-half.

Stated very crudely, the number of animals in the fattening herds divided by the rate of intake of store animals would give the length of the feeding period. It follows that if the number of heifers in fattening herds was inflated by the inclusion of cows being fattened, then the average age of heifers at slaughter must also be inflated. The author, of course, employed a much more detailed method than the crude one he had himself described for determining the age of slaughter, but in so far as the size of the heifer herds must be smaller and the rate of throughput therefore greater than she had allowed, the age of slaughter must be lower than that recorded in Table 16.

With regard to the lactation cycle, if thirteen months were accepted as the cycle, then it followed that the pattern of monthly cow calvings must be stepped back each year by one month, and farmers, in order to maintain a definite pattern of calvings, must vary, each year, the monthly intake of down-calving heifers. But if one looked at the author's graph No. 6, showing the number of heifers calving, it would be seen that the peak of heifer calvings occurred in the autumn of each year. It did not suggest those adjustments in monthly heifer calvings which would seem to be necessary in order to maintain the over-all pattern of all calvings.

He wished to make one further observation on heifers in calf. Why was it that the quarterly estimates of home-reared heifers entering the herds as given in Table 23 did not tie up with the details given in Table 31 showing the heifers in calf at the June census? There might be a perfectly reasonable explanation for that, but Table 31 showed that, at June 1940, there were 594,000 heifers in calf—nearly the same as the number recorded by farmers. In other words, the author was saying by implication that 594,000 heifers would calve-down over a period of nine months after June 1940. From Table 23 it would be seen, however, that if the calvings over the periods from June to August 1940, September to November 1940, and December 1940 to February 1941 were added together to get the total for nine months the figure was 609,000. As he had said, there might be reasonable explanations as to why these figures should not be the same, and it would be useful to know why they did not agree.

The following comments were received in writing:

Mr. H. T. Williams and Mr. H. Palca: We have read Miss Marley's paper with considerable interest, and wish to congratulate her upon her industry and upon the ability with which she has pieced together data derived from a variety of sources to form a comprehensive survey of the cattle industry in Great Britain in recent years.

In a general way, the results of Miss Marley's analysis confirm the tentative conclusions on the changes occurring in livestock husbandry which have been reached by most people concerned with agricultural statistics and with the practical side of the livestock industries. On the other hand, some of the specific results of the analysis, such as the extent of the lengthening of the fattening period for beef cattle, particularly heifers, and the discrepancy between the recorded and estimated numbers of in-calf heifers, are almost certain to surprise many.

On the assumption that the numbers of livestock (other than heifers in calf) as recorded at each census are substantially correct, the accuracy of the results in the above respects depends in very high degree on the accuracy of the estimate of the final outflow from each class of livestock. The outflow is based upon (*a*) the recorded numbers of animals of each class purchased and slaughtered by the Ministry of Food; (*b*) an estimate of the number of animals of each class included in the total of casualties purchased by the Ministry of Food, and for which separate classification is not available; and (*c*) upon an estimate of the deaths due to natural causes. Of these three sets of figures in so far as they relate to any particular class of animal the first can probably be regarded as being the most firm, but even in this case it might be pointed out that the Collecting Centre returns (apparently used by Miss Marley) tend to understate the numbers

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purchased. Thus foot and mouth disease contact salvages are excluded, as also are certain other types of casualties and late presentations. The discrepancy between total Ministry of Food purchases and collecting centre numbers have amounted usually to about 4,000 to 5,000 head a quarter, or 15,000 to 20,000 head a year.

In regard to animals classed as casualties total figures only are available, and all that is known of them with any degree of certainty is that the majority are derived from the cow population.

The estimate of total natural deaths of "mature" cattle is based upon the statistics of hides purchased by the Ministry of Supply. The paper makes no mention of any adjustment to this figure to allow for the deaths of animals from which not even the hides are salvaged, as in the case of animals affected with foot and mouth disease, which, though in some years are of negligible numbers, in others are quite appreciable. Even with deaths other than those attributable to foot and mouth disease, farm burial of the unflayed carcase, while frequent for young animals, is not uncommon for mature ones. On the face of it there seems some grounds for suggesting that the total wastage from natural deaths has been under-estimated.

Having arrived at an estimate of total natural deaths, Miss Marley has used a straightforward proportional method to distribute them among the three classes of stock-cows, heifers and steers. There is some reason to believe that this method understates the natural death rate of cows, subjected as they are, unlike other classes of cattle, to the strenuous and artificial conditions attendant upon intensive milk production.

How would errors in these various estimates affect the results of the inflow-outflow analyses and the age distributions set out in this paper? As regards beef steers, it does not seem likely that any considerable errors are likely to occur. Under-statement of the numbers slaughtered by the collecting centre returns may be cancelled out by over-estimation of the wastage due to natural deaths. In the analysis of the female side of the industry, however, which is based upon the calculation of the outflow of milk cows, there is a strong suggestion that the errors are all on the side of under-estimation. This may explain in part the considerable excess of recorded heifers in calf as compared with the numbers estimated by Miss Marley. In turn it may be the cause of calculating an excessive inflow of heifers to the beef herds, with the consequent result of a disproportional increase in the length of the feeding period of heifers during the war years. A further factor tending to exaggerate these errors would be that mentioned by a speaker at the meeting, that barren dry cows are included in the returns as female other cattle 2 years old and over. The latter point would be most important at a time of drastic culling.

There are one or two further points concerned with the technique of the analysis. In the estimate of the numbers of Irish heifers on farms in December 1939 account has been taken only of imports and slaughterings. Does this not lead to an underestimation of the stock, in that during this period some number of those most suitable would have been bulled or transferred to dairy herds?

Dr. George has emphasized that the use of a standard calving interval period could lead to cumulative errors if there were wide variations among individual cows. Such wide variation is believed to exist. From an analysis of an 8 per cent. sample of Milk Recording Society herds in England in 1934, it was found by one of the writers that the average interval between calving was indeed nearly 13 months, but that nevertheless less than one half of the cows actually calved at an interval of between twelve and fourteen months.

Even the adoption of a standard gestation period may lead to error, in that it is subject to significant variations. From an analysis of 1·5 thousand cows in English M.R.S. herds in 1937/8, it was found that only 7½ per cent. calved on the day expected, and that about an equal proportion calved down over a week stretching before and after the expected date. Quite an appreciable proportion were yet wider of the mark, even though the analysis omitted all cases where the time overdue or premature exceeded 21 days. These findings agree with those published by research workers elsewhere.

In addition to the foregoing, we would like to make one or two comments of a more general character. Miss Marley in her introduction rightly draws attention to the value of vital statistics prepared for each group of cattle as aids to future planning. We agree that such vital statistics may be of great help in anticipating the broad trend of events. But it should not be forgotten that, unlike vital statistics relating to the human population of this country, those relating to livestock are extremely sensitive, not only to environmental changes such as those occasioned by the weather, but also to markets and prices. The former, through its influence on fodder supplies, can, in the short run at least, alter very appreciably the seasonal pattern of marketing, as witnessed by the extremely heavy slaughtering in the autumn of 1946 following an exceedingly bountiful grazing season. In regard to the latter, it should not be forgotten that during the period under review by Miss Marley, increasing price inducements towards maximizing output of meat have been offered, and these cannot have been without some effect on agricultural practice. Again,

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in the short period the effect of price changes on marketings is apparent on examination of the raw data relating to periods adjacent to the introduction of new price schedules. On the whole, therefore, in the short term administration of the country's food resources, as distinct from long-term planning, the purely statistical approach is almost certain to be too rigid, and to lead to completely unreal forecasts of events.

Mr. M. H. QUENOUILLE: I should like to comment on two of the tables given by Miss Marley in her paper.

Firstly, in Table 1, as Miss Marley has mentioned, there will, for example, in December 1941, be some animals older than 36 months. This is a result of the varying size and constitution of herds, which cause some younger animals to be killed "before their turn." I do not believe that this fact will affect the subsequent figure of average age of slaughter greatly, since at the next killing, both younger and older animals than those indicated by the table will be killed, tending to balance any bias. Even if the bias is not totally removed, the error in the estimated average age will tend to be constant, so that comparisons may be made. What might be of greater importance is the fact that errors in the figures for new entrants will accumulate in the highest age group, giving a variable error in the average age of slaughter. For example, an underestimate of the new entrants by 2,000 for each of the first three quarters of 1942 will result in a figure of 1,000 instead of 7,000 for the age-group 36–38 months in September–November. Perhaps Miss Marley could tell us if such an error as 2,000 is unlikely in the new entrants.

Secondly, concerning Table 3, Miss Marley remarks that a secondary peak occurs in March and April. This peak seems to depend entirely on the figures for 1940, and in particular upon the large drop in imports occurring after May 1940. Since this drop can be attributed to other causes, I feel that there is some doubt about the existence of this peak.

Mr. J. H. KIRK: I should like to join in the congratulations which have been extended to Miss Marley on this valuable pioneer work. This sort of dissection of the official statistics, designed to disentangle two or three rather separate industries whose statistics are, so to speak, shared in common, and to establish trends for the industries taken separately, is of great value to the Agricultural Departments for purposes of policy and administration; and I am glad that officials of the Ministry have been able to assist Miss Marley at various stages in her work.

But with how much confidence can we accept the results? The ingenuity of Miss Marley's methods is obvious from the paper, and so is the painstaking way in which she has built up her results step by step. But this process of building up step by step demands the utmost accuracy at each stage. It is on this aspect of the matter that I feel it difficult to accept Miss Marley's results without at least some reservations. She has been at great pains to check her working, and to consult expert opinion, but even so, those of us who have to handle these statistics day by day cannot but feel a few doubts.

One point which occurs to me is that Miss Marley appears to have taken at their face value farmers' estimates of the ages of their cattle. In point of fact cattle ages are largely conventional. Cattle are often entered as yearlings at ten months, and as two-year-olds at 21 months. If, as I suspect, Miss Marley has not made a correction for this factor, it must follow that her age distribution is not quite right, and I fancy—without having checked the point—that her population tables of beef and dairy cattle taken separately are also affected.

A more general comment concerns her inferences from the census statistics as to the numbers of store or beef cattle. Rather too many cattle appear to me to be described as in this category. Our statistics of two-year-olds and upwards (apart from cows and heifers in milk or in calf) include temporarily barren dairy cows, dairy heifers which were not successfully mated at the usual time, and dairy cows being fattened for slaughter. It is surely not right to regard these classes of cattle as being store or beef cattle, and if so, we seem to have an over-estimation of the beef herds throughout the period of study and, I might add, an increasing over-estimation year by year. Corroboration of this view is suggested by a comparison of Miss Marley's beef herds with beef output; the output per 1,000 beef animals on farms appears to have fallen much more than one would be willing to attribute to the known factors, such as the undoubted fact that the period of fattening has lengthened.

My final comment concerns the slaughter of calves and the replenishment of herds by imports. Taken without explanation, Miss Marley's figures, which show that no less than half the calves are slaughtered in their first year, and one-third of that number is then made good by imports, are rather startling. There is, I believe, a good explanation. Cattle rearing is an extensive enterprise, dependent on cheap land and labour, which need not be carried on in proximity to consuming centres. Over a long period a natural division of labour has developed. Cattle are reared in their early years in Ireland, Wales and the remoter parts of Scotland, while the nearer-in

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parts of England and Scotland have concentrated on dairying and cattle feeding. It would be uneconomical for many farmers in the latter areas to rear all their calves—even as many as are required for replacement—so they slaughter a high proportion of their calves, and replace with animals reared under cheaper conditions. Various circumstances, such as disease factors, are, however, tending to limit this division of labour and to encourage what is called home-rearing. It is, however, one of the most interesting features of Miss Marley's paper that this territorial differentiation within the cattle industry has been so clearly brought out, and for the first time given quantitative expression. To have the cattle import and calf slaughtering figures brought into juxtaposition and made to suggest these inferences is in itself an important contribution.

Miss MARLEY thanked Dr. George and Professor Jones and the other speakers for their very kind reception of her paper. She had been extremely interested in the discussion and would look into all the points that had been raised. In the shortened version of her paper much of the descriptive material was sacrificed, and she was a little troubled about this, as some of the points raised in the discussion were actually points she had discussed in the longer version. Her reply to the discussion as a whole would be made after she had had an opportunity of seeing the report of the remarks.

Miss Marley subsequently wrote as follows:

The first point that I should like to deal with concerns the age at which cattle pass from the "under one year" to the "yearling" class. I am aware of the common belief that the "yearlings" returned at the census may be only 10½ months old or, as Mr. Kirk suggests, 10 months old; and similarly, that the cattle "two years old and over" may be only 21 months. If such a practice were commonly adopted it would have been so serious to the outcome of the investigation that at the outset I made very careful enquiries before I accepted the broad age-classification used in the Agricultural Census. Two checks were open to me—one through direct enquiry and one statistical. Whilst it was impossible to adopt sampling methods, I did consult farmers and other expert opinion regarding the method of distinguishing cattle by age. I found no evidence that a calf born late in the summer would necessarily be a "yearling" at the next June census. But it was emphasized that it was often difficult to ascertain the correct age of young cattle purchased in the market, and, furthermore, that some farmers fail to keep adequate records of the date of birth. However, there seemed no reason why the error arising from such lack of knowledge should be biased one way or the other. Thus, while my circle of enquiries was very small, I had no ground for believing that any tradition or convention led normally to any overstatement of the animals' ages in the census return. The impression I obtained in this way was strongly reinforced by the statistical check. It will be remembered that the number of "surviving replacement cattle" was calculated taking together eight of the three-monthly age groups. These figures, given in Table 32, show a figure varying between 370,000 and 650,000 for animals which fail to reach the age of two years. In the original paper this question is gone into rather more carefully, and it is further shown that the estimated "surviving population" of calves for rearing (i.e. animals under twelve months, excluding calves for slaughter) compares extremely well with the figure returned by farmers on eight separate occasions. It follows that if farmers were to return their animals as yearlings at the age of nine months instead of twelve months the difference between the estimates and the census population would be very large. We should in fact lose a complete three-monthly age group. To make this clear the two sets of estimates are shown below, one assuming that farmers correctly return their animals, and one assuming that they are returned as yearlings when only nine months.

Calves for rearing

Thousands

	Census population	"Surviving population"			
		Twelve months		Nine months	
		Estimate	Difference	Estimate	Difference
1939 December	1,554	1,474	80	993	561
1940 March	1,488	1,311	177	936	552
September	1,565	1,377	188	1,081	484
December	1,551	1,398	153	1,080	471
1941 March	1,432	1,335	97	895	537
June	1,465	1,371	94	1,048	417
September	1,444	1,426	18	1,109	335
December	1,466	1,403	63	1,148	318

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The Table shows that in every case when the twelve months' assumption is made the estimated figure of calves known to survive is a little below the census figure. This is a satisfactory result, since the census figure will be reduced by natural deaths and the other figures will not; and furthermore, it is clear that only a slight degree of error in the estimates would be required to upset the balance. The nine months' assumption, however, results in a difference of 300,000 or more.

Put in another way, if the first age group represents animals only 0–9 months and the second group animals 9–18 months, then the census totals could only be accounted for by a much larger inflow, and similarly a much larger outflow to all the mature classes. Whilst the home-reared recruits to the beef classes are now estimated at roughly 800,000 a year (Table 14), the results of adopting the 9 and 18 months' concept would be an inflow of over a million, and such an inflow is quite inconsistent with the known figures of slaughter. The first part of the calculation is logically quite independent of the age factor, as it is immaterial whether 21 or 24 months is taken as the base when computing the average age at slaughter. But in the later sections dealing with herd replacement this change cannot be made without producing results inconsistent with much of the other data—either the "surviving population" would become attenuated, or else the inflow to all mature classes would be impossibly high.

Dr. George also mentions the springers from Ireland. I fully recognize the difficulty mentioned here, but since I am dealing throughout in thousands, any error arising from springers failing to drop a calf makes little or no difference to the final results. It was, of course, necessary to decide on a procedure with regard to springers, and I chose to include them amongst the new entries one month after they arrived in the country. But since they rarely amount to more than one or two thousand in any one month, any inaccuracy resulting from faulty reporting here can make no difference to the general picture.

Another interesting point raised by Dr. George concerns cows which are dried off. The pre-war practice of fattening cows for market after their last lactation was well known to me, and an allowance for this factor would have been made in the calculation had I not been advised that this practice was uncommon during the war owing to the acute shortage of feeding stuffs. No extra rations are allowed for a fattening cow, and the usual procedure is to fatten the animal *during* and not after the last three months of the lactation. Nevertheless, the queries raised both by Dr. George, Mr. Kirk and Mr. Smith made me feel that a further check would be of interest. I thus completely re-worked the figures of the average age of slaughter for heifers, assuming (*a*) that all the cows are transferred to the beef heifer class and (*b*) that only half the cows are transferred. The results are as follows:

Estimated average age at slaughter of heifers assuming transfer of fattening cows to beef class

Months

	Half cows transferred		All cows transferred	
September	Age	Difference	Age	Difference
1942	41·0	1·0	41·0	1·0
1943	41·0	0·3	40·4	0·9
1944	40·5	0·8	40·0	1·3
1945	40·8	0·6	40·2	1·2

I chose the month of September as being the most representative, since at this time slaughterings are heaviest and the "inflation" of the beef class by fattening cows would be greatest. Taking the more extreme of these assumptions (100 per cent. transferred), the number of "transferred cows" works out at about 20 per cent. of the population and not "anything from one-third to one-half" suggested by Mr. Smith. At other times of the year the "inflation" due to this factor would be much less—in March, for instance, the proportion would be nearer 10 per cent. and, of course, considerably less with the second assumption.

To turn to Dr. George's difficulty regarding the Eire imports in 1943, the explanation here is quite simple and a reference to it is to be found on p. 197. Since diversions to the milk herds were made from both home-reared and imported heifers, it follows that not all the imports of Eire heifer stores actually increase the store population. With further reference to the "disappearance" of Eire cattle, I did not make any allowance for natural deaths in this class because the number of deaths is too small to make any significant difference.

I am sorry that the economic terms used in the paper were not as clear as they might have been; but the section devoted to the discussion and justification of the terms used had to be completely sacrificed in the condensing process.

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I am very grateful to Professor Bradford Hill for drawing my attention to his investigation of the mortality rates of calves. I was interested to see that his figure of 5·5 per cent. for the loss of calves during the first six months of life agrees quite well with my 1945 estimate in Table 47. Furthermore, his information relating to abortions allows me to calculate the degree of under-estimation in my heifer-in-calf figures (Table 31). Previously I could make no estimate of the number of heifers that slipped their calves during the gestation period, but using his figure of 5·5 per cent. and recalculating on this basis I find that my net figure for 1944 could be raised by about 20,000, or between 3 and 4 per cent. I assumed for the purpose of calculation that abortions took place after six months' pregnancy. Furthermore, the loss to rearers from this cause can now be calculated. In 1945, for instance, I estimate that the net monetary loss (that is, assuming that the heifers subsequently command a store price) to be in the region of £650,000.

In examining the figures of disappearance from the beef store class mentioned by Messrs. Williams, Palca and Smith, blackmarket transactions, disposals due to foot-and-mouth disease, farm interments, etc., were all very carefully investigated. But none of these factors led me to make any but the most minor adjustments. It has also to be borne in mind that in a quantitative study, using a unit of a thousand, such factors have to be very substantial before they can affect a month to month comparison. Furthermore, the statistics I received from the Leather Control giving their figures of hides obtained from the Ministry of Food gave a most satisfactory check.

My decision to distribute the total figures of natural deaths amongst the three classes in proportion to the mean populations at the appropriate census dates was only taken after a careful examination of statistics of natural deaths provided by the Ministry of Agriculture of Northern Ireland. Furthermore, if we insist on a higher wastage of cows (and thus a higher inflow to tie in with the recorded heifer-in-calf figures), then the annual wastage of beef and dairy cows would rise to well over 30 per cent. compared with 23 per cent. in 1940, and the rate of natural deaths would double over the same period. These results are inconsistent with the published estimates derived from direct enquiries, which agree well with the rates shown in Tables 26 and 27.

The method used by Mr. Smith in his estimates of intake into the dairy and breeding herds was experimented with in the initial stages of this enquiry, but it had to be discarded when it was found that the results were wholly inconsistent with published data. Only a phenomenal increase in the wastage rates of dairy and beef cows could account for the very large intake which would have to accompany the recorded increase in the number of heifers in calf.

Mr. Smith's difficulties regarding the estimates of intake appear to be due to the fact that he has failed to grasp the significance of the statistical method adopted. The quarterly census return for September 1941 shows 622,000 heifers in calf. For the reasons given on p. 215 I believe this figure to be inflated, and I estimate the net total (i.e. excluding heifers that slip their calves) at the much lower figure of 340,000. Thus when an allowance is made for 7,000 imported springers, the estimate of 347,000 is obtained for heifer calvings. Similarly, Mr. Smith is puzzled because my June figure of heifers in calf, 549,000, appears inconsistent with the number of heifers calving down in the following nine months. He will find the explanation in the heading of Table 23—the total calvings include those of 15,000 springers from Ireland.

The pattern of "monthly cow calvings" queried by Mr. Smith depends on a number of factors, of which the length of the calving cycle is only one. Both the volume and seasonal pattern of past intake (for at least six years) and of current disposals are equally important. The seasonal pattern of calvings obtained was checked and found to be consistent (*a*) with the pattern of rearings (Graph 8), which is obtained quite independently and (*b*) with the figures of total wastage of replacement cattle, which are themselves closely governed by the slaughter data (Graph 9).

Mr. Williams and Mr. Palca raise a point regarding the length of the "lactation cycle." As I explained, my estimate of the number of calves born to cows already in the herds is very tentative. The thirteen months' cycle is adopted as the most reasonable interval, and I was therefore extremely interested to learn that this average is confirmed by the sample enquiry undertaken by the Milk Recording Society. There cannot, however, be any question of the adoption of a standard calving period leading to *cumulative* error. Any error in the estimate of total births is reflected only in the wastage figures (Tables 38 and 47 for example), and can in no way influence the main analysis, which deals only with "surviving births."

Mr. Quenouille mentions two points, the first regarding the possible under-estimate of new entrants to the beef class. The only statistics that are in some doubt at this point are those of entrants from Northern Ireland. As I mentioned on p. 204, some Northern Irish stores are known to be below the age of two years at the time of import. These, however, average less than two thousand a month (Table 15) if males and females are considered separately. Thus the error could not amount to as much as 2,000 in the monthly new entrant figure. With regard to Mr. Quenouille's second point, the statement to which he refers alluded to a paragraph mentioning heifers separately which was included in the original paper. This statement should, of course

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have been deleted when the paragraph was omitted from the published paper, and I am obliged to Mr. Quenouille for pointing out this error, which I have since corrected.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Frank Bamforth.
Manjeshwar Dayananda Bhat, M.A.
Alfred Arnold Dewey.
Harry Fell.
Evelyn Helena Gibson, B.A.
John Griffith.
Trivandrum Sunramania Iyer, M.A., B.Com.
Vasudeva Bantwal Kamath, M.Sc.
Michael Thomas Kavanagh, A.R.C.S., B.Sc.
John Edward Leary.
John Arthur Moore.
Leonard Pearce Mould.
Aeron C. Rogers, M.A., B.Sc.,
Alfred William Ross, M.A.
James Francis Spink, Litt.D., Th.D., Ph.D.
Rene Claude Taylor, B.A.
Alan Frederick Wootton.

Corporate Representatives

Eileen Mary Beek, *representing* Guthrie & Company, Ltd.
Albert Jennings, *representing* Murphy Radio, Ltd.

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MISCELLANEA

Standard Errors of Means in Sampling Surveys with Two-stage Sampling

By H. Fairfield Smith

In a review of the methods of sampling surveys Yates (1946) has given the formulae for computing standard errors of estimated means in ordinary cases which have proceeded according to plan. Occasionally for one reason or another the sampling fractions get out of control and the formulae then become more complex. For example, in a survey of rubber small holdings,* some observations, such as thickness of bark in tapping, could only be obtained on those holdings which were tapping during the month of observation, an event which varied with the district, thus erratically altering the planned sampling fractions in so far as these characters were concerned. In this investigation it was found convenient to derive a general formula from which the estimate of error for each special case could be quickly deduced. The derivation of the appropriate formulae is implicit in the papers of Yates (1946), Yates and Zacopanay (1935) and Cochran (1939), but a statement of the general form may save time for others who have need of it.

We consider sampling in two stages, say districts and farms (*cf.* Yates, 1946, Sec. 5c). Let the population consist of N districts with K_i farms in each, $i = 1, 2 \ldots N$. We sample n districts, observing the variate x on k_i farms in each, $i = 1, 2 \ldots n$. It is required to evaluate the standard error, or variance V_m, of the weighted mean:

$$\bar{\bar{x}} = \frac{1}{W} \sum_{i=1}^{n} w_i \bar{x}_i$$

where $W = \sum_1^n w_i$, and $\bar{x}_i$ is the mean for the ith district,

$$\bar{x}_i = \frac{1}{k_i} \sum_{j=1}^{ki} x_{ij},$$

$\bar{\bar{x}}$ being regarded as an estimate of the population mean,

$$\bar{\xi} = \frac{1}{\Omega} \sum_{i=1}^{N} \omega_i \xi_i,$$

where $\Omega = \sum_1^N \omega_i$, and ξ_i is the population mean of the ith district

$$\xi_i = \frac{1}{K_i} \sum_{j=1}^{K_i} x_{ij}.$$

Usually $w_i = \omega_i = K_i$ (except that for $n < i \leqslant N$, $w_i = 0$), but this is not necessarily so: for example it may sometimes be desired to allow for varying accuracy of the means from different districts, or other conditions may be present; for example in the particular problem under investigation owing to destruction of records it was not always known which district contributed which set of observations, and the districts had perforce to be weighted equally or in proportion to the number of observations.

* To be published in *Journ. Rubber Research Instit. of Malaya.*

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Following the usual conventions in analysis of variance, each observation is regarded as the sum of two independent parts and we write

$$x_{ij} = \eta_i + \varepsilon_{ij},$$

where η_i is assumed constant throughout the ith district and varies between districts with variance V_d; and ε_{ij} varies about zero mean with variance V_i in the ith district. From the observations we obtain analysis of variance as follows:

	d.f.	S.Sq. is an estimate of
Between districts	$n-1$	$\left(\Sigma k_i - \frac{\Sigma k_i^2}{\Sigma k_i}\right) V_d + \Sigma V_i - \frac{\Sigma k_i V_i}{\Sigma k_i}$
,, farms within district 1 . .	$k_1 - 1$	$(k_1 - 1)\, V_1$
,, ,, ,, ,, i . .	$k_i - 1$	$(k_i - 1)\, V_i$
,, ,, ,, ,, n . .	$k_n - 1$	$(k_n - 1)\, V_n$

Regarding both the population and the observations as a sample and sub-sample of some infinite population we have, following Cochran (1939), p. 506,

$$(\bar{\bar{x}} - \xi) = \sum_{i=1}^{n}\left(\frac{w_i}{W} - \frac{\omega_i}{\Omega}\right)\eta_i - \frac{1}{\Omega}\sum_{i=n+1}^{N}\omega_i\eta + \sum_{i=1}^{n}\left(\frac{w_i}{Wk_i} - \frac{\omega_i}{\Omega K_i}\right)\sum_{j=1}^{k_i}\varepsilon_{ij}$$

$$- \frac{1}{\Omega}\sum_{i=1}^{n}\frac{\omega_i}{K_i}\sum_{j=ki+1}^{K_i}\varepsilon_{ij} - \frac{1}{\Omega}\sum_{i=n+1}^{N}\frac{\omega_i}{K_i}\sum_{j=1}^{K_i}\varepsilon_{ij}$$

where each part of the expression on the right is independent. Then

$$V_m = E(\bar{\bar{x}} - \xi)^2 = \left[\frac{1}{W^2}\sum_{1}^{n}w_i^2 + \frac{1}{\Omega^2}\sum_{1}^{N}\omega_i^2 - \frac{2}{W\Omega}\sum_{1}^{n}w_i\omega i\right] V_d$$

$$+ \left[\frac{1}{W^2}\sum_{1}^{n}\frac{w_i^2 V_i}{k_i} + \frac{1}{\Omega^2}\sum_{1}^{N}\frac{\omega_i^2 V_i}{K_i} - \frac{2}{W\Omega}\sum_{1}^{n}\frac{w_i\omega_i V_i}{K_i}\right]$$

If $k_i/K_i \to 0$, i.e. if the sampling fraction within districts is small, terms in K^{-1} may be neglected; if $n/N \to 0$, that is if the district sampling fraction is small, terms in ω/Ω may be neglected. If V_i may be regarded as equal in all districts the analysis of variance of course reduces to the usual form with a single pooled estimate within districts, $= V_o$, say; $\Sigma V_i - \Sigma k_i V_i/\Sigma k_i = V_o\,(n-1)$ and V_o can be taken outside the second bracket in the formula for V_m. However, under the conditions of survey work, as contrasted with the usual applications of analysis of variance to experimental data, the number of observations in each district will often be sufficient to give a reliable estimate of the variance in each district separately; and if n is small, or the districts may be classified into only a few groups with approximately equal variances, the arithmetical labour of recognizing their variation may not be excessive.

If the number of districts (N) is small so that terms in $(\omega/\Omega)^2$ are appreciable, it is of some interest to note how the error of the estimated mean is affected by varying weights in the population means of districts *not* sampled.

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If V_i is constant $= V_o$, $w_i = 1 (i \leqslant n)$, $\omega_i = 1$, $W = n$, $\Omega = N$, K and k are constants, $n/N = f_1$, $k/K = f_2$, we have the case considered by Yates (*loc. cit.*) and the above formula reduces to

$$\left(\frac{1}{n} - \frac{1}{N}\right) V_d + \left(\frac{1}{nk} - \frac{1}{NK}\right) V_o = (1 - f_1)\frac{V_d}{n} + (1 - f_1 f_2)\frac{V_o}{nk}$$

which is the same as the formula given by Yates (p. 19) if V_d be replaced by the formula for estimating it from the mean squares of the analysis of variance. Obviously the general formula could be written in terms of the mean squares, but to avoid complexity it is generally easier to estimate V_d as a preliminary to estimating V_m. The formula using mean squares is only required if one wants the constants by which mean squares are multiplied in order to estimate the variance of V_m. This, however, will not usually be required. The mean square between classes by itself provides a sufficient estimate of the error variance of the mean only when the first stage sampling fraction tends to zero, and both k_i and V_i are constants; but it may often serve for practical purposes if these conditions are approximately fulfilled.

Literature Cited

COCHRAN, W. G. (1939), *J. Am. Stat. Ass.*, **34**, 492.
YATES, F. (1946) *J. Roy. Stat. Soc.*, **109**, 12.
YATES, F. & ZACOPANAY, I. (1935), *J. Agric. Sci.*, **25**, 545.

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REPORTS FROM COUNCIL AND NOTICES TO FELLOWS

The Certificate Examination of the Royal Statistical Society

The first Certificate Examination open to Fellows of the Society was held on December 19 and 20 in the Statistical Laboratory of the Department of Medical Statistics at the London School of Hygiene and Tropical Medicine. Twenty-three candidates sat the examination, 20 taking all four parts and 3 offering Sections A and B only. Seven candidates satisfied the examiners in Sections A and B only, one in Sections C and D only and ten in all four Sections—A, B, C and D—thus completing the examination for the Certificate. The ten candidates awarded the Society's Certificate were:

Brown, John.
Garreau, Gabriel Armand.
Garstang, Roy Henry.
Keen, Joan Ethel.
Owen, Gerald Victor.
Palca, Henry.
Pridmore, Wilfrid Alan.
Taylor, John.
Ward, Denis Hugh.
Wilson, William Arthur.

Copies of the examination papers set at this the first of the Society's examinations can be had for 1s. post free on application to the Assistant Secretary.

Notice to Fellows and Members of Sections with Regard to the Submission of Papers

The Council wish to do everything to encourage Fellows and Members of Sections to contribute papers to the Journal and its Supplement. They particularly welcome the contributions of younger Fellows who are in a position to bring forward new material, methods, or problems.

All papers should be sent to the Assistant Secretary or one of the Honorary Secretaries. Those intended for reading at a meeting of the Society or Research Section are submitted to two referees appointed by the Council or Research Section Committee. The referees report as to the suitability of a paper for reading at an Ordinary General Meeting or meeting of the Research Section and for subsequent publication in the Journal or Supplement. If the paper is accepted a date is arranged in accordance with the Sessional programme and to suit the convenience of the author. The paper is then printed so that proofs may be available to those attending the meeting and so that copies may be sent, before the meeting, to Fellows, Members of Sections, and others who are particularly interested in the subject matter and who might wish to take part in the discussion. Before publication the author has the opportunity to revise the proof. A reasonable amount of correction is allowed at the Society's expense, *but the paper should be as nearly as possible in its final form and proofs should not be used as drafts for further revision.* Papers submitted for publication only are considered by the Editors of the Journal or Supplement, who decide as to their suitability, taking, if necessary, the advice of referees.

Authors of papers accepted for reading must furnish the Assistant Secretary with (*a*) an abstract of the paper, in about 300 words, for issue to the Press, and (*b*) a synopsis, or note of the main heads for printing on the admission card, as a guide to the paper's contents and the line of development followed. The press abstract is not needed for papers to be read before the Research Section.

Whatever the length of the paper, authors should restrict the amount read at the meeting to occupy not more than half an hour, so that time may remain for effective discussion. As those present have proofs it is usually best for the author to read those parts of the paper which will best develop his arguments and illustrate his thesis, guiding the audience by reference to the appropriate galleys. A summary form different from the proofs in the hands of the audience is rarely satisfactory. At the meeting the author need not make any detailed reply to points raised

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in the discussion. He will be able subsequently to study them at leisure and to make a considered reply in the Journal or Supplement. Contributions to the discussion are published and proofs are sent to the contributors before publication. Contributors are asked to confine themselves, when correcting the proofs, to minor alterations or grammatical improvements and not to alter the substance of their remarks, as this may make the rest of the discussion unintelligible.

Papers communicated to the Society become its property, but the Council will always sympathetically consider applications for reproduction in full or part elsewhere, e.g. in a book to be published by the author. No remuneration is given to an author, but after publication 25 reprints (with the discussion) are given free of cost for private distribution. The author may also purchase further copies at cost price if paper is available.

Fellows and Members of Sections who are considering the preparation of a paper for submission may discuss their problems with one of the Honorary Secretaries. He, or another Fellow deputed by the Honorary Secretaries, will do his best to advise the author, though it must be realized that he can take no responsibility for final acceptance of the paper.

Fellows and Members of Sections will realize that the Council are dependent upon them for the maintenance of the Society's high standard of meetings and publications. They hope, therefore, that Fellows and Members will freely submit papers for reading so that the Council may be in a position to construct a yearly programme ranging over a wide field of statistical problems and of interest to the equally wide range of the Fellowship. Published papers are annually considered by the Council for the award of a Guy Medal.

The following notes apply both to papers submitted for reading before the Society or Research Section and to papers to be published without reading in the Journal and Supplement.

(1) *General Instructions.*—Papers should be typewritten, but legibly written documents are acceptable; *formulae* should always be handwritten (NEVER TYPED) and great care taken to make them legible. Two copies, if possible, should be submitted. They should be typed or written on one side of the paper, on sheets of uniform size, numbered consecutively, and with at least one inch of margin. It is desirable that they should not exceed 16 pages of the Journal or Supplement, or about 12,000 words after making due allowance for tables and diagrams. They may well be considerably shorter.

(2) *Diagrams.*—These should be drawn in black ink on separate sheets of white paper, with numerals and lettering in pencil. Any cross-lines which are not be to reproduced should be in blue.

Tables.—These should have clear but concise headings and, whenever possible, should fit the printed page.

(3) *Footnotes.*—Footnotes should not be placed at the foot of the sheet but immediately under the line to which they refer, enclosed by two horizontal lines drawn across the sheet.

(4) *Mathematical Formulae.*—Much trouble and expense in printing are saved by the avoidance of symbols which are difficult to set up. The Society has a supply of the Notes on the Preparation of Mathematical Papers issued by the London Mathematical Society, and any Fellow who wishes to submit a mathematical paper should obtain a copy from the Assistant Secretary.

(5) *Summary.*—At the end of the paper there should be an effective summary of its contents.

(6) *References.*—These should not appear as footnotes, but should be set out in alphabetical order at the end of the article and arranged on the Harvard System, as follows:

(*a*) Name and initial(s) of author, in that order.

(*b*) Year of publication in brackets, distinguished by the addition of small letters a, b, c to the date where more than one paper published by the same author(s) in the same year is cited.

(*c*) Contracted title of periodical mainly as given in *World List of Scientific Periodicals*, and printed in italics (indicated by underlining), with the exception that all adjectives in English title should commence with a capital letter.

(*d*) Volume number in arabic figures in bold type (indicated by underlining with a wavy line), followed by beginning page number of article. Series numbers, where necessary, must be placed in brackets immediately preceding the volume number.

(*e*) When a book is cited the title should be printed in italics, followed by edition number, place of publication and publisher.

(*f*) The use of ibid., op. cit., loc. cit. in the references is not desirable.

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References will then read as follows:

Brown, A. B. (1926), *Proc. Roy. Soc.* A, 123, 76.
Brown, A. B., & Jones, C. D. (1926), *Pflug. Arch. ges. Physiol.*, 26, 34.
Field, A. C. (1926), *Nature, Lond.*, 130, 26.
Hunter, A. B. (1920), *Physical Chemistry*, 3rd. ed. London: Macmillan.
Jones, E., & Brown, C. (1936), *Ann. Mag. Nat. Hist.* (2), 26, 330.

The following list shows the contracted titles from the *World List* most frequently met with in statistical literature:

American Journal of Mathematics. *Amer. J. Math.*
American Naturalist. *Amer. Nat.*
Annales de l'Institut Henri Poincaré. *Ann. Inst. Poincaré.*
Annals of Eugenics. *Ann. Eugen., Lond.*
Annals of Mathematical Statistics. *Ann. Math. Statist.*
Biometrika. *Biometrika.*
British Journal of Psychology. *Brit. J. Psychol.*
Economic Journal. *Econ. J.*
Empire Journal of Experimental Agriculture. *Emp. J. Exp. Agric.*
Giornale dell'Istituto italiano degli attuari. *G. Ist. ital. Attuari.*
Journal of Agricultural Science. *J. Agric. Sci.*
Journal of Educational Psychology. *J. Educ. Psychol.*
Journal of the Institute of Actuaries. *J. Inst. Actu.*
Journal of the Royal Statistical Society. *J. R. Statist. Soc.*
Supplement to the Journal of the Royal Statistical Society. *J. R. Statist. Soc. Suppl.*
Mathematische Annalen. *Math. Ann.*
Metron. *Metron.*
Nature. *Nature, Lond.*
Philosophical Transactions of the Royal Society. *Philos. Trans.*
Proceedings of the Cambridge Philosophical Society. *Proc. Camb. Phil. Soc.*
Proceedings of the London Mathematical Society. *Proc. Lond. Math. Soc.*
Proceedings of the Royal Society. *Proc. Roy. Soc.*
Proceedings of the Royal Society of Edinburgh. *Proc. Roy. Soc. Edinb.*
Sankhyā: the Indian Journal of Statistics. *Sankhyā.*
Skandinavisk Aktuarietidskrift. *Skand. AktuarTidskr.*
Studia mathematica. *Studia math.*

In the text, references should be denoted by giving the name of the author and the date of publication, in brackets, e.g. (Brown, 1926), (Brown, 1926*a*; Jones & Smith, 1924*a*, *b*). Where the name(s) of the author(s) form(s) part of the sentence the date is inserted in brackets after the name, e.g. "Brown (1926) in a paper on . . ." Where a particular page is cited reference should be made as follows: (Brown, 1926, p. 12).

When two authors are quoted as collaborating the names should be joined by "&," e.g. (Brown & Jones, 1926).

Where more than two collaborating authors are quoted the first name only should be given followed by *et al.*, e.g. (Brown *et al.*, 1926) *not* (Brown, Jones & Smith, 1926).

If the author wishes to add the titles of papers, these should be inserted between inverted commas (not in italics) after the date; capitals should be used only for proper nouns.

(7) *Proof Correction.*—The British Standards Institution has prepared a *Table of Symbols for Printers' and Authors' PROOF CORRECTIONS.* A copy will be sent on request to authors whose papers have been accepted for publication. Only the more commonly occurring symbols need be used. It is easier to give clear instructions to the printer in words (which should always be placed in a square or circle to indicate they are not to be printed) than to use unfamiliar symbols.

The Council are indebted to Professor E. S. Pearson for allowing extensive quotation from the guide to authors of papers in *Biometrika.*

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

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1.—*Probit Analysis: A Statistical Treatment of the Sigmoid Response Curve*. By D. J. Finney. With a Foreword by F. Tattersfield. Cambridge University Press, 1947. xiii + 256 pp. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. 18*s*.

Dr. Finney has produced a first class book. One of the disadvantages of specially invented terminology is that it is apt to suggest reconditeness; a probit however is in all essential respects a normal deviate—that deviation from the mean expressed as a multiple of the standard deviation which is exceeded with a given frequency. It has become customary to add five to the normal deviate and call the result a probit. If the least stimulus which will produce a certain characteristic response in an individual is called his tolerance and a suitable function x of the tolerance is normally distributed, then if the probit which corresponds to P—the proportion of individuals in which the response is produced, in the universe under consideration—is plotted against x, a straight line is obtained. The slope of the line is the reciprocal of the standard deviation of the universe.

The technique for obtaining from actual data estimates of the position and slope of such lines and the sampling errors of these estimates is called probit analysis. Its importance in application is very great, especially in the field of biological assays which depend on a *quantal* or "*all or none*" response.

A biological assay, strictly speaking, is an attempt to find out from a trial with living creatures of some particular species how much of a given substance is present, per cent. weight or volume, in a preparation containing the substance. For example, from an assay with rats we may make an estimate of the vitamin A content of a cod-liver oil. Biological assays are usually used, originally, when the exact chemical constitution of the substance is unknown; but it is often convenient to go on using them after the constitution has become known, because of the difficulty of actually isolating and measuring the extremely minute quantities which are present. A cod-liver oil, for example, might contain one milligramme of vitamin A per gramme.

In a slightly more general sense if two substances each produce a characteristic effect on members of a particular species of living creature, a comparison of the amounts necessary to produce the same effect—amounts which may or may not be in the same ratio at all levels of response, though they usually *are* in actual applications—may be called a biological assay.

Dr. Finney's book covers the field of statistical technique necessary in dealing with biological assays, defined in this wider sense and depending on quantal responses. His own contributions to the subject have been mainly concerned with the toxicities of insecticides, and many of his examples have been drawn from that source.

The first five chapters give an excellent account of the usual theory and practice of the method. The main treatment is rightly based on the maximum likelihood solution, though graphical and other approximate methods are briefly considered. Section 14, Chapter 3, is devoted to an interesting historical account of the probit method. Fechner seems to have been the real discoverer of the method, which he used in discussing the distribution of just perceptible differences in weight. The least difference which an individual can correctly detect may, on a suitable scale, be regarded as his tolerance for discrimination. Other psychophysicists followed up the idea, notably Müller, Urban and Thomson. The credit for introducing the method into biological assay work must

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be ascribed mainly to Gaddum's 1933 paper. Gaddum had an intimate knowledge of the field with which he was dealing from the point of view of a professional pharmacologist, and though his work seemed rather difficult reading at the time, it was in fact better than much that was written after it. In particular he used the correct form of the χ^2 test, before the maximum likelihood method had been obtained by Fisher—an example of the value of good scientific judgment.

In Chapter 5 there is a remarkably good section (21) on the combination and comparison of relative potencies; in one example non-orthogonal analysis of variance is skilfully used. The reviewer would like to recommend this, quite apart from probit-analysis, as the clearest exposition he has seen of how to apply non-orthogonal analysis of variance in practice. Section 22 is very short, but rightly emphasizes the importance of experimental design, and envisages the further use that can be made of modern design in this field.

Chapters 6, 7 and 8 are mainly concerned with important developments due to the author himself. Chapter 6 develops the technique necessary for allowing correctly for a natural mortality not caused by the stimulus applied. The maximum likelihood equations become more complicated, but the pilot clearly steers the course to be followed. Chapter 7 is equally good, and shows how to deal with the case when the response has to be related to *two or more* stimuli, which may or may not interact. Chapter 8 deals with the toxic action of mixtures of poisons. Here the author's exposition of his own contributions is first rate; but the chapter suffers a little in clarity from his careful attempt to be courteous to other writers. The difficulty in the subject seems to be due to the use of the ambiguous term "*independent joint action*." The term "*similar joint action*" is quite clearly defined; the poisons or drugs produce similar effects in the sense that one component can be substituted at a constant proportion for the other, and variations in individual susceptibility to the two components are completely parallel. This last statement is to be taken literally, the curves relating reponse to log-stimulus are parallel in the two components and in the mixture, and the ambiguous phrase "similar but independent effects" in Bliss's original definition is modified by the omission of the last three qualifying words. "Synergism," positive or negative, is then defined as departure from similar action.

Though the term "*independent joint action*" is so ambiguous that its use in connexion with this subject should probably be banned altogether, just as the term "*minimum lethal dose*" has been in other connections, it is worth while trying to clarify our notion of its meaning. The equation

$$ {}_jP = {}_jP_1 + {}_jP_2(1 - {}_jP_{1|2}) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1) $$

—where ${}_jP$ denotes the probability of the characteristic effect being produced by a mixture of definite amounts of two poisons (the suffix j denoting that the poisons are applied jointly), ${}_jP_1$ is the probability that the characteristic effect is produced by the dose of the first poison, whether it is produced by the second or not; and ${}_jP_2$, ${}_jP_{1|2}$ have the usual analogous definitions—is true whenever the symbols have a meaning. They cease to have a meaning if the two poisons react to form a chemical compound, for then we cannot speak of the probability of one producing an effect whether the other does or not. It does not follow that ${}_jP_1$ is the same as the probability that the dose of the first poison produces the characteristic effect when it is administered by itself.

Bliss spoke of action as independent whenever equation (1) held, except that he wrote $(1 - {}_jP_1) \times (1 - r)$ for $(1 - {}_jP_{1|2})$ and took no account of the suffix j. It would, however, be better to confine the term independence to cases in which ${}_jP_{12} = {}_jP_1 . {}_jP_2$, i.e. independence in the statistical sense.

It is to be noted that the correlation coefficient between the "susceptibilities" to the two poisons, where susceptibility is defined to be 1 when the effect is produced and 0 if it is not, is

$$ \frac{{}_jP_1 + {}_jP_2(1 - {}_jP_1) - {}_jP}{\sqrt{\{{}_jP_1\ {}_jP_2\ {}_jQ_1\ {}_jQ_2\}}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2) $$

while the coefficient r in Bliss's formula has the same numerator, but denominator ${}_jP_2 . {}_jQ_1$ $({}_jP_1 > {}_jP_2)$. Bliss's r is not a correlation coefficient and the author notes this. Thus except when the poisons react to form a new compound all action is independent in the sense of (1); but similar action, except perhaps for one particular pair of dosages, is not independent action in the statistical sense; indeed such action would rarely, if ever, occur.

Chapter 8 ends with an interesting example of a compound response curve, such as would arise when the proportion of the two constituents in a mixture is a function of the concentration. A probit log-dose relation of the form

$$ Y = a + b \log\{\rho + (1 - \rho)\, 10^{-k\lambda}\} + b \log \lambda \quad . \quad . \quad . \quad . \quad (3) $$

where λ is the concentration, ρ the relative potency of the two components, is derived, which for $\rho < 1/(e^2 + 1)$ has both a maximum and a minimum.

Chapter 9 is concerned with some miscellaneous problems, heterogeneity of response in batches of animals on the same dose, the treatment of individual mortality records when only one animal

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receives each dose, with the *average kill*, and with the theories of Parker Rhodes which involve an equation of the form

$$Y = \alpha + \beta\lambda^i \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In equations of this form i cannot be determined precisely from the data usually available, but the quantity $1/ib^2m^2$, where b is the slope estimate, m the median effective dose, changes very little with i.

It is to be noted that if (4) be written in the form

$$\begin{aligned} Y - 5 &= (x^i - \mu)/\sigma \\ &= \{(1 + i \log x + \ldots) - \mu\}/\sigma \end{aligned}$$

and we write $\mu' = (\mu - 1)/i \quad \sigma' = \sigma/i$

and let $\mu \to 1$, $\sigma \to 0$, $i \to 0$, μ' and σ' remaining finite we obtain

$$Y - 5 = (\log x - \mu')/\sigma' \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

so that (5) is a limiting case of (4) when $i = 0$. This discussion brings out the fact that the normal equivalent deviation is sometimes easier to use in theoretical discussions than the probit; the same applies to the "average kill," where the use of the quantities $\alpha = 5 - (\mu/\sigma)$ and $\beta = 1/\sigma$ is distinctly awkward. We may require to know the expected kill when a selected average dose is given, but the individual doses are normally distributed about a mean ξ with variance γ^2. If the probit-dosage relationship for whole groups is

$$Y - 5 = (\xi - \mu)/\sigma \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

the proportion receiving the dose x will be $(2\pi\gamma)^{-\frac{1}{2}} e^{-\frac{1}{2}(x-\xi)^2/\gamma^2}\, dx$ and the proportion of those receiving it who are killed by it will be

$$\int_{-\infty}^{(x-\mu)/\sigma} (2\pi)^{-\frac{1}{2}} e^{-\frac{1}{2}u^2}\, du \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Thus the expected mortality of the group will be given by

$$\begin{aligned} P &= \int_{-\infty}^{\infty} dx\, (2\pi\gamma)^{-\frac{1}{2}} e^{-\frac{1}{2}(x-\xi)^2/\gamma^2} \int_{-\infty}^{(x-\mu)/\sigma} (2\pi)^{-\frac{1}{2}} e^{-\frac{1}{2}u^2}\, du \\ &= \int_{-\infty}^{\infty} dt\, (2\pi)^{-\frac{1}{2}} e^{-\frac{1}{2}t^2} \int_{-\infty}^{(\xi-\mu+\gamma t)/\sigma} (2\pi)^{-\frac{1}{2}} e^{-\frac{1}{2}u^2}\, du \quad . \quad . \quad . \quad . \quad . \quad . \quad (8) \end{aligned}$$

whence $$\frac{dP}{d\xi} = \{2\pi(\sigma^2 + \gamma^2)\}^{-\frac{1}{2}} e^{-\frac{1}{2}(\xi-\mu)^2/(\sigma^2+\gamma^2)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

so that P is the mortality whose probit is $5 + (\xi - \mu)/\sqrt{(\sigma^2 + \gamma^2)}$. The effect of spreading the doses is thus the same as increasing the variance of tolerances by γ^2. The treatment in the text obscures this.

The last chapter shows that probit analysis may occasionally be useful in dealing with graded responses. If there is an upper limit to a graded response, the probit corresponding to the response expressed as a proportion of this limit may be linearly related to some function of the dose. This is illustrated by some data on the uptake of lime sulphur by the honeybee. In fitting, the necessary weighting involves the variances of the original response at the different dosage levels. These will not in general be known *a priori*; the author assumes them to be equal; and this will often, as here, be quite a good enough assumption. But a transformation which equalizes the transformed variances sufficiently closely for practical purposes saves all the labour of obtaining the maximum likelihood solution by successive approximations; and it will often be possible by transformation to find a linear relation for which the transformed variances can be regarded as equal. Thus the probit method is not likely to be the best method very often, in dealing with graded responses.

This book should serve as a model to others who intend to write a text-book on a particular statistical technique. It demands a little more mathematical knowledge from the reader than some books which have purported to explain statistical methods to the research worker who is not a mathematical specialist. On the other hand, it is not too difficult for the mathematically minded to fill in the gaps either for themselves or by reference to original papers. The balance is very well preserved. Further, one has the feeling that the author really understands the methods himself—he will pardon this seeming platitude—but this cannot be said about all text-books which

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have attempted to explain modern statistical methods while easing the path for the non-mathematical. There has been, at times, too much tendency to quote this or that authority, without really understanding the original work or the limitations of the field of applicability implicit in its original presentation. We congratulate the Lecturer on the Design and Analysis of Scientific Experiments in the University of Oxford on the successful performance of a difficult task.

J. O. I.

2.—*Statistical Methods in Research and Production, with Special Reference to the Chemical Industry*. Edited by O. L. Davies. London and Edinburgh: Oliver & Boyd, 1947. $9\frac{3}{4}'' \times 6''$. xi + 292 pp. 28*s*.

This handbook was originally written for internal use in I.C.I., and has now been extended and made available to a wider public. Although the Introduction only professes to have brought together those methods most likely of use in the chemical industry, workers in other lines will also benefit from a study of this book. It can be recommended to those wanting to become acquainted with statistical methods, without spending much time on the mathematics which justify any particular technique. We agree with the editor that "the only satisfactory way to acquire a working knowledge and understanding of the methods is to work out fully a number of typical examples" (p. 74).

The execution of such a programme is largely a matter of taste and teaching experience, and no rules can be laid down about how to make the reader see the essential point without confusing him with too much theory. For the mathematically minded a formula will always be more meaningful than words, but an author cannot always rely on estimating correctly the extent of the earlier training of his readers. On the other hand, some readers will be allergic to a collection of rules, when they have to take the author's word for their justification. On the whole, in the reviewer's opinion the line has been drawn with sound judgment. The following extreme examples are meant as illustration rather than as criticism of the presentation. The method of least squares in connection with straight line regression is explained (App. 6A, pp. 146 *seq*.) in such detail that the most pedantic reader will be satisfied. On the other hand, App. 5L (pp. 116 *seq*.) dealing with the estimation of a missing value gives, quite correctly, Yates's formulae, but without a hint as to their reason. We do not understand why, in the case of more missing values, there should be "no 'exact' formula for estimating them" (p. 117), but we agree that in such cases "a statistician should be consulted," which phrase appears in other places as well and circumscribes the scope of the book. The Analysis of Variance with proportionate frequencies in subclasses is again dealt with by rule of thumb, and it is impossible that a reader should guess that there are some subtle points of interpretation involved.

After an introductory chapter, referring rather frequently to later pages (which is, perhaps, unavoidable in a book of this origin), there follow two chapters on Frequency Distributions, Averages and Measures of Dispersion. A chapter on Tests of Significance precedes the treatment of Analysis of Variance (using examples from chemistry, not from agriculture) and of Regression and Correlation. The reviewer, at any rate, fully agrees with the readable account of their respective merits, and he does not regret the omission of correlation indices. Two typical regression problems, called rather quaintly the "Rubber Testing Type Regression" and the "Penicillin Type Regression," are exhaustively treated. The next chapter is on Frequency Data and Contingency Tables, followed by chapters on Sampling and on Control Charts. They may be necessary, but they could be improved when the next edition is prepared, with less traces of haste left. The final chapter on Prediction and Specification appears to bring together all information which could not be incorporated organically on any previous page. (Credit for the so-called "Camp-Meidell"-inequality should, incidentally, be given to C. F. Gauss). An account of the logic of statistical inference, in particular that of estimation, might usefully be added.

Even in normal times this book would be called well produced. It contains the usual set of tables (normal, chi-squared, *t* and *F*-distributions, critical values of the correlation coefficient and of the binomial and Poisson distributions, control chart limits), and a nomogram. Where appropriate the tables are followed by neat graphs showing clearly which areas are given in the respective tables. Other graphs are printed in the main text, but are not entirely satisfactory. Whereas the reproduction of the same scatter diagram—that of Abrasion Loss *vs*. Hardness—on three different pages (118, 124 and 132), first without addition and then with superimposed regression lines and standard deviation limits respectively, will find the reader's approval, some other graphs are much less informative, consisting of thin lines set in a large rectangle taking up far too much space (see fig. 2.1 on p. 6 for an example of what a graph should not look like).

At the end of chapters, References are given. Their choice must depend on personal judgment, but a few remarks may be in order. There exist accounts of the Analysis of Variance with dis-

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proportionate subclass numbers which are more readily available in this country than Snedecor and Cox's Iowa Research Bulletin (p. 96), and it is surprising that Snedecor is not mentioned elsewhere. Neyman is only mentioned once, as the co-author of the (unexplained) L_1-test, to which "the Bartlett test is to be preferred." The Behrens test is mentioned without a hint as to the niceties of its interpretation, let alone the doubts about its legitimacy. Incidentally, can the Fisher-Yates tables be called a "text-book"? (p. 142). Barnard's paper in the *Suppl. J.R.S.S.* on Sequential Analysis is, justly, mentioned, but Wald's work on the same subject seems to have been unknown to the authors.

We are glad to read in Lord McGowan's foreword that this is only the first of a series of handbooks to be published by I.C.I., and that the Preface promises more specifically a sequel on Planning of Experiments. We do not doubt that the present publication will contribute to spreading sound statistical knowledge and contribute to its taking its place among other useful arts.

S. V.

3.—*Teorica della Sopravvivenza.* By Filadelfo Insolera. Turin: Vincenzo Bona, 1947. $7'' \times 10''$. 243 + xii pp. 1000 *lire.*

This book is an enlarged version of the first part of Insolera's *Corso di Matematica Finanziaria*, of which a second edition was published in 1937. The subject dealt with in the new book is actuarial theory apart from problems involving interest and excluding any general treatment of graduation. The main changes as compared with the *Corso* are the inclusion of an account of King's abridged method of constructing mortality tables from population statistics, the insertion of several sets of figures based on mortality tables from population and insurance offices' experiences, additional work on select mortality among assured lives, a fuller treatment of invalidity and some additional explanatory matter. There has been no change in the general approach, and though much of what the author says is interesting, it is a pity that he did not clear up some doubtful points in his treatment of the subject, modernize his approach, and take his examples from tables that are in daily use instead of from tables nearly all of which are merely of historical interest.

The first few chapters deal with elementary functions and the author uses his double approach, namely, by taking the l_x of the Life Table and by also taking Δ_x which stands for all those who have died up to age x among l_0 people born, the underlying idea being that there are two forces at work, mortality and vitality. Though the author uses certain derived functions in subsequent work, it does not appear that there is much gain to balance the duplication. When discussing the old vexed question of a limit to the duration of human life—a problem that seems more urgent when we approach it through the "Life Table" than if we adhere to rates of mortality at successive ages—he gives alternative statements of the limiting age ω, in one of which $p_\omega = 0$ and in the other $p_\omega > 0$ by a quantity which is < 1; similarly with q_ω. If $p_\omega = 0$ and $q_\omega = 1$ we reach what he regards as incomplete rates; if $p_\omega > 0$ and $q_\omega < 1$ we reach, with an adjustment, complete rates of survivorship or mortality at the final age. He extends the idea to earlier ages, and (p. 50) gives equations which show the force of mortality (μ_x) as the difference between the two sets. It is hard to see what purpose these "complete rates" serve, and the treatment becomes more confusing when he implies that the force of mortality will not exceed unity, whereas if $q_x \to 1$ then $\mu_x \to \infty$.

After dealing with the elementary functions the author discusses the Gompertz-Makeham hypothesis, the earlier hypotheses of de Moivre and others and the suggestions of Lazarus and Wittstein, and mentions Karl Pearson's analysis of d_x by frequency curves, but he does not refer to any more recent hypotheses.

In the later part of the book the author examines the effect of medical (or other) selection on the rates of mortality, and the tables that can be made when there are two operating influences, such as mortality and invalidity. Much of this is interesting, but here again there is no reference to modern work.

The book is based on Insolera's own papers written over a number of years, and though it is pleasant to have those dealing with a branch of actuarial work collected in this way, it would have been more attractive if the author's work had been related to the efforts of other people in the same sphere. In fact one puts down the book with the feeling "that art stopped short at the cultivated court of the Empress Josephine."

A word of caution must be given as to notation. The same symbol is used with different meanings in different chapters, *e.g.*, the l_x of Chap. III is not the l_x of the "Life Table" in other chapters; E_x in Chap. III is the exposed to risk and in Chap. II is the complete expectation of life.

As has been explained, we think the book would gain by revision and modernization, but it must be remembered that though published in 1947, it was written a few years earlier in circumstances that must have added greatly to the author's difficulties—circumstances to which he refers at the end of his preface in terms that capture the sympathy of the reader.

W. P. E.

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4.—*Manual de Estatística*. By Amaro D. Guerreiro. Instituto Nacional de Estatística, Portugal. Lisbon, 1947. 310 pp. 9″ × 6″. 60 *Escudos*.

This book is issued from the National Institute of Statistics of Portugal under the authorship of an economic statistician, and follows the traditional lines of the economic statistical text. Thus, after opening with examples to give the notion of the frequency distribution, it contains chapters on measures of location (mean, median, mode, etc.), on moments and measures of dispersion, and on measures of asymmetry and kurtosis. Further chapters deal with the calculation of the correlation coefficient, the correlation ratio, and partial and multiple correlation, together with the regression concept and methods. The rest of the book is given to chapters on Index Numbers, on the analysis of time series, and on the fitting of curves to data. Apart from the simple case of the binomial, this last chapter deals (in some considerable detail) with examples of fitting Pearson curves.

The subject-matter is treated descriptively throughout, and the author goes into painstaking detail to ensure that the calculation of all the various measures is thoroughly understood, numerous examples being worked out arithmetically. It is open to question, however, whether the economic statistician is any longer satisfied with a treatment which leaves the subject at this stage, and does not really touch on the important problem of the use to which the various measures, fitted curves, etc., are to be put. In particular, the author does not discuss how one would proceed to compare a mean calculated from one sample of data with another from a second sample. When it is realized that the well-known formula for the standard error of a mean is not given, it is not surprising that problems of estimation and tests of significance are not treated at all. A very full table of the normal curve is given, principally for use in fitting such a curve to data, although the meaning of the area under such a curve is also dealt with in what is called the probable error of regression. The other tables relate to the logarithmic Gamma function and to χ^2, the only use of the latter being to measure the goodness of fit of curves to frequency data.

The book will be of value to beginners in the study of economic data because of the description given of index numbers, and of the methods of graduation suggested for smoothing out fluctuations in time series. It would have been of still greater value had it dealt with practical sampling problems, even if the theory of random sampling associated with tests of significance had to be omitted. As it is, the serious student will require to complete his statistical education with the aid of other textbooks before he will be in a position to handle effectively the tools of his trade.

M. J. R. C.

5.—*Food, Famine and Relief*, 1940–46. Geneva: League of Nations, 1946. 9″ × 6″. 162 pp. 6*s*.

This book is the third by the author dealing with the effect of the war on food consumption. The first half contains an examination of the position up to the end of the war, with a final chapter reviewing public health during the same period. It is essentially an interim report, and is supplemented by three short chapters on the situation as it appeared from the latest estimates of supplies available at the time of writing (May, 1946). The author forecast the continuation of world food shortages, but although one chapter is devoted to the early history and achievements of U.N.R.R.A. there is no hint of the coming political difficulties that ultimately led to the winding-up of this body or of the developments that have given rise to the Marshall Plan.

The chief feature of the book is the description and analysis of food consumption levels in each principal country; where possible both the consumption of the chief food groups and the resulting nutritional levels are examined; the author is handicapped, however, by the lack of consistent and complete statistical material; there are few countries for which the information on supplies is as satisfactory as that in the reports on the *Food Consumption Levels in the United States, Canada and the United Kingdom*.

For consumption levels in Germany and German Occupied Europe the author has recourse to estimates of consumption as calculated from the official rations. This method is possible for this group of countries because each had a rationing system covering the great majority of foodstuffs; even so, the analysis strictly applies only to urban consumers, and to those who were unable to supplement their diet from the black market. But in many countries even where food shortages were common during the war the rationing system was less well developed or not so complete and this procedure could not be followed. As a result the treatment of each country is largely determined by the amount of material available. On one hand, some 40 pages are covered in dealing with Germany and its satellite or occupied countries, whereas conditions in the Far East are dismissed in a few paragraphs.

As the German countries are analysed in such detail some comment on this part of the book is relevant. The basic material for this section is set out in an Appendix, which gives useful and comprehensive tables of the legal rations in some 20 countries from 1940 to 1945. The study is,

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however, confined to consumption levels, and does not include a description of the administration of food rationing or of the developments that were necessary to make it effective. When a study on this aspect is possible one point worth investigating is the grading of adult workers. Rationing systems of the German type are highly differentiated, allocating different quantities of the more important foods, such as bread, meat and milk to children, adolescents and heavy workers. Where the differentiation is based on some clear difference of needs due to sex and age no difficulty arises, but in the case of "heavy workers" one would like to know whether the selection of each individual was based on some objective standard such as output, or whether economic or political considerations were involved.

The highly differentiated nature of these rationing systems leads to another difficulty. As the national importance of each type of consumer is not known the author is unable to obtain national averages, and instead compares the consumption of a "typical family," consisting of man, wife and three children. Family types are extremely diverse, and it is very doubtful whether in any country a standard family of this composition is at all common; in the United Kingdom under 4 per cent. of families are of this type. Further, the standard family chosen grossly overweights the importance of children, which make up 60 per cent. of its persons, whereas in no European country is the proportion anywhere near as high as this, and in many it is much nearer 25 per cent.

This over-representation is unfortunate because, as is shown (p. 29), children were the most favoured group, while adolescents and heavy workers were worse off relative to their needs. Had the latter groups been included by using a standard more nearly equivalent to an average family the conclusions would probably not have been so favourable.

This applies both to the use of the standard family in the international comparisons with requirements (p. 37) and to the comparisons with pre-war (p. 31). The pre-war figures are derived from budget inquiries which are quoted without an indication of their source. Incidentally, no comment is made on their lack of agreement with the estimates of per capita calorie intake derived from supply estimates quoted on p. 84. It appears, however, from earlier publications that the budget inquiries quoted were for the most part on a small scale, and contained in some cases rather larger families than the standard family used here. It is doubtful whether the reduction of all families to averages per consumption unit overcomes this difficulty or that caused by the over-representation of children in the standard family.

There is one further point which may mislead and which illustrates the care required when discussing consumption as indicated by legal rations. On p. 29 the milk rations shown for the United Kingdom ignore the extra milk for nursing mothers and that distributed at school to children. The latter increases the child's entitlement in term by 50 per cent., but neither supplement is mentioned until p. 60, and then only in another connection. W. F. F. K.

6.—*The Population and Epidemics of Exeter in Pre-Census Times.* By Ransom Pickard, C.B., C.M.G., M.S., F.R.C.S. Printed for the author by James Townsend, Exeter, 1947. 8¼″ × 5¼″. 83 pp. + charts.

If you go to the libraries where most you would expect to find a copy, say, of 40 years ago of one of the Annual Reports of a Medical Officer of Health of any town in which you are interested, you will probably be told that reports of that and even more recent periods have been destroyed on account of insufficient book-storage space. It is well that the custody of civic health documents of much earlier periods have not everywhere suffered a like fate. The population and epidemics of Exeter where the records in pre-census times have been preserved would then, like those of cities bereft of their records, have remained utterly unknown.

In his efforts to rescue vital statistical facts and practices of hygienic interest, Dr. Ransom Pickard has had perforce to work with centuries-old parochial registers of baptisms for the dates and numbers of his births and of burials for those of his deaths. Of population, the basic datum in vital statistics, no such specific records exist, and estimates based on Hearth Tax as used by Creighton and other indirect approaches are the best available in the pre-censal centuries. Dr. Pickard has employed a different method of reintegrating the populations of the period with which he deals. The ratios of births to population as ascertained during the census years of the nineteenth century are assumed to have remained generally uniform in their range throughout the previous centuries examined in Exeter. By multiplying the numbers of Exeter Registers of baptisms by the ascertained censal period maximum, mean, and minimum ratios of births to Exeter populations and making certain corrections for omissions in the Registers, etc., population figures for any period are estimated. These maximum, mean and minimum populations for each decennium from 1580 to 1800 have thus been calculated. The differences between them and population figures obtained from Hearth Tax records are discussed and other data are examined and compared. Whatever the errors to which the estimates are subject, this method tentatively

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of exploring a statistical field lacking in established or otherwise discoverable facts is contributory to a revival of by-gone happenings. In the course of centuries, however, the ratios of births to population may easily exceed or fall below the maximum and minimum found during the later censal century. Variations in the age and sex constitution of the populations which must have occurred alone would alter the actual contemporary ratios materially and out of proportion to the ascertained ratios of the later period. Notwithstanding the limiting value thus imposed upon a novel essay, Dr. Pickard is nevertheless to be congratulated on his ingenious method of penetration into a domain otherwise one of uninformed guesses or a continuing unillumined nescience.

The epidemiological results of his enquiries are also interesting. The seasonal incidence of plague in Exeter, similar in the three epidemics 1570–71, 1590–91 and 1625–26, as he points out, is characteristic of plague. The high autumn mortality with its maximum in September is, it is interesting to note, in accord with the account given by Defoe in his *Journal of the Plague Year in London*. The epidemiologist will find much of interest with regard both to plague, smallpox and other epidemics in this record of Dr. Pickard's investigation into the visitations of these diseases to Exeter. Although, as in other towns where they have been preserved, the Exeter registers are not complete, nevertheless, in his dealing with the epidemics of Exeter, he has given a sustained and interesting picture of the ancient course of epidemic diseases in that town and of the efforts for their control, which in principle and aim were more rational than might be expected and were many of them not so far removed from those of preventive medicine in our own time.

Dr. Pickard has resorted in his tables and charts to forms with which contemporary practice has made us familiar, and it is a tribute to his industry that so much of remote happenings is thus displayed in modern guise.

W. B.

7.—*The Population of the Soviet Union: History and Prospects.* By Frank Lorimer, Princeton University. League of Nations, Geneva, 1946. $10\frac{5}{8}'' \times 8\frac{1}{8}''$. 289 pp.

No complete census of Russia was taken until 1897, and since then but two more have been held, in 1926 and in 1939. Only partial returns are available in respect of the latest of these, as publication of the full data has been seriously held up by the war. Although vital statistics have been tabulated from time to time the records are neither continuous nor wholly accurate. In these circumstances it is difficult to present a properly balanced account of the Russian population, and any general survey is apt to consist of a mixture of enunciations of certain known features in great detail and of speculations about the remainder. Thus, in this book, four chapters are devoted to an exposition of the results of the 1926 census and to its related registration data. These are the best modern data available and their description forms the core of the whole work. The contiguous chapters deal more broadly with the probable changes in the first and second quarters of the present century respectively, and are preceded on the one hand by a general historical and economic introduction, and succeeded on the other by a final section dealing with possible future movements.

The meagreness of this demographic material in the face of the vast changes brought about by two world wars and a major revolution has precluded any possibility of accurately assessing population trends. This is sufficiently illustrated by the margin of error found in 1939 in the projection of the Russian demographers, Novoselskiy and Payevskiy, who, working apparently in the early nineteen-thirties, made a single calculation of the numbers to be expected at the beginning of 1939. Their estimate was 191 millions, whereas the total of those actually enumerated amounted to no more than 170 millions, or over 10 per cent. less; only a part of this difference is due to changes in fertility. In the circumstances it is not surprising that Russia can provide no new types of demographic information, nor is any fresh light thrown in this account on changes in human populations generally. Such special techniques as are used are in the nature of makeshifts for utilizing data collected in a rather unsuitable form.

Nevertheless, an examination of the extensive bibliography reveals that almost all the previous books and papers on the subject were in Russian and were therefore inaccessible to all but a very few. It was clearly desirable that an attempt should be made to compile a work of reference in English for general purposes, and in particular as a preliminary to the preparation of Prof. Notestein's estimates of *The Future Population of Europe and the Soviet Union*, the relevant sections of which are used in the concluding chapters of this book to give an indication of possible future demographic developments.

Viewed in this way, the work is of undoubted value and, in spite of its imperfect perspective, the product of thorough research. The text is appropriately illustrated by a long series of maps, charts and tables.

P. R. C.

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8.—*Income: An Introduction to Economics.* By A. C. Pigou. Macmillan, 1946. vii + 118 pp. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. 5*s*.

In this book, intended as an introduction to Economics, Professor Pigou accepts the validity of the traditional notion of an optimal equilibrium situation towards which the workings of a capitalist private enterprise economy automatically and constantly tend, subject to "friction," to drive productive resources, *via* the operation of the price-system. If competition acts freely, the "invisible hand, of which Adam Smith spoke, will so contrive that the pursuit by each of his own private interest in the field of production will promote the aggregate interest of all" (p. 72).

This notion of equilibrium is fundamental to Professor Pigou's whole argument. The validity of the notion, in the sense that it should correspond to the facts and real tendencies of the actual capitalist world, is taken for granted by him throughout the argument. But scrutiny of the assumptions underlying this notion shows that it is not a valid one, by the test of correspondence to the realities of the capitalist world.

The crucial assumption of the argument is that the total volume of resources mobilized for production and allocated to the different branches of production by the workings of the private enterprise system is equal to the total volume of available and required resources. This assumption is at the very base of the whole traditional, classical system of economic thinking, but it is, in fact, in contradiction with the truth. Professor Pigou never really subjects this fundamental assumption of classical economics to the test of facts. He does state the problem, *ambulando*, in Ch. VI, which is entitled "*The proportion of income-getting power at work on the average and at different times*," but his manner of doing so shows that he has a preconceived faith in the validity of the classical assumption, which prevents him discussing it at all thoroughly. This is betrayed, at the outset, by the fact that this really crucial chapter in which the problem of the extent of resource-utilisation under private enterprise should be discussed, does not precede, but comes *after* the chapter on "*The role of Government in production*" (Ch. V), in which Professor Pigou has already expressly given his blessing, in a general way, to the classical notion of equilibrium, in advance.

When he does discuss the problem, his treatment of it is unworthy of the subject in hand.

Professor Pigou does not, in fact, describe, even in a rough way, the chief influences by which the average proportion of income-getting power which is actually at work is determined. What he does is to suggest implicitly, but without giving evidence or proof, that there is, in fact, a mechanism inherent in capitalism which makes for full resource-utilization. He ignores all but the most glaring and well-known facts to the contrary, and then gives us a theory, not of how the degree of resource-utilization is *in fact* determined, but of how some of the evidence of failure in this respect could be accounted for even on the assumption, which Professor Pigou appears to expect his readers to take for granted with him, that private enterprise automatically leads to full resource-utilization.

He first of all says that, of the different elements which make up income-getting power, there are only good statistics about labour-power. He then suggests that "the activity of this and that of industrial equipment presumably vary more or less together. We may, therefore, reasonably use the percentages of would-be wage-earners who are actually employed as a rough indication of the extent to which the country's income-getting power is being exercised" (p. 85). Next, Professor Pigou tells us that the unemployment returns collected by certain unions of skilled workers over a half a century up to 1914 can be interpreted as showing that in that period "of the available labour about 6 per cent. was unemployed." The average of the inter-war period was about 14 per cent. according to unemployment insurance statistics. He stresses that, in spite of a rapid increase, through natural growth, of the working population, "on the average of the second as well as on that of the first period, by far the predominant part of the available labour-force was not idle against its will, but was exercising its income-producing power" (p. 86).

These facts Professor Pigou implicitly accepts, without analysis, as establishing the truth of the classical postulate that, in a private enterprise economy, productive resources are normally fully utilized. He says: "So much for the facts. We have now to try to explain them. First, why was the average level of unemployment so much higher in the inter-war period than it had been before 1914?" (p. 86). Professor Pigou answers this question by suggesting that the explanation of the heavy unemployment of the inter-war period lies in a "maladjustment" (the word is significant) between aggregate money outlay and the mean rate of money wages, which in turn was due to the effect of compulsory State-aided insurance against unemployment on Trade Union psychology. The theory here is that Trade Unions always cause unemployment by insisting on higher rates of wages than would result under competition, which would cause full employment to exist. The price of Trade Union action is that they cause suffering to their members and a drain on their own funds, and this double check restrains their unreasonableness. State financed unemployment insurance to some extent mitigates the burden of the operation of these checks,

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causes Trade Unions to become more unreasonable, and establishes a new, higher average level of unemployment (pp. 87–9).

This is all that Professor Pigou offers us in explanation of how the average degree of income-getting power is determined under capitalism. But it is evident that this is a partial *apologia* for an unstated theory of automatic full resource-utilization, and not an explanation of the determination of the degree of resource-utilization at all. The omission is a serious one, for several reasons. The level of income-getting power per head of population depends on their skill and industry, on the amount and quality of land and the quantity and character of capital equipment and organization in a community. By omitting to discuss how changes in these fundamental determinants of the standard of living come to be what they are in a capitalist community, Professor Pigou is enabled to dispense altogether with an examination of the Keynesian theory of effective demand. No doubt Professor Pigou felt justified in doing this, since Keynes's theory is widely held to be primarily a theory of unemployment, regarding which Professor Pigou has, as we have seen, his own views.

In truth, however, the Keynesian theory of effective demand is necessary to an understanding, not only of problems of unemployment, but also of the fundamental problems of scientific and technical change, capital accumulation, land utilization, foreign trade and industrial organization.

In avoiding to consider analytically what determines the fundamental elements of income-getting power, Professor Pigou's treatment not only leads him to omit all reference to vitally important new developments in economic doctrine which may supersede the main body of traditional economic teaching altogether, but incidentally also causes him to ignore highly suggestive relevant facts. And in the field of labour-utilization it is surely not legitimate to assume, as Professor Pigou does, that a high level of employment is proof of the full use of the energies of the workers. There is no involuntary unemployment in the British building industry to-day, but would anyone claim that this labour is being fully utilized? And may there not be a connection between the slackness of labour and the environment of capitalism?

The basic assumptions of Professor Pigou's thinking would be called into question by many economists seeking a clear introductory account of economic science for first-year students. These basic assumptions pervade the exposition of every chapter of this book. The truth is, that for the time being no satisfactory introductory book on economics exists in the English language. This is because the revolution in Western economic thought which is associated with the influence of Lord Keynes's work has not yet run its course. Shortly the deceptive lull induced in the field of academic economics by wartime preoccupations of economists will be over, and it will not be possible to persist in the illusion "that the field over which the general body of economists are substantially agreed, so far, at all events, as qualitative analysis is concerned, is a large one" (p. 118).

J. K.

9.—*Small and Big Business : Economic Problems of the Size of Firm.* By J. Steindl, Oxford Institute of Statistics, Monograph No. 1. Oxford: Basil Blackwell, 1945. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. v. + 66 pp. *7s. 6d.*

This is an extremely interesting and stimulating book, in which the author puts forward an ingenious theory of the size of firm. Moreover, it is in the true Oxford tradition—associated with the name of Mr. Kalecki—of attempting to integrate economic theory with available statistical data.

There are really two distinct aspects of the problem which Mr. Steindl tackles. The first is the relationship between size of firm, in the sense of the size of capital investment necessary to operate at any given size, and the profitability of such investment. The second problem—with which the book starts and ends—is concerned with why the small firm manages to exist at all in the face of competition from technically superior larger firms. But it is the answer to the first problem that constitutes the essence of Mr. Steindl's book.

As a first approximation, Mr. Steindl emphasizes the "principle of asymmetry," *i.e.*, that all economies internal to a small firm are also open to larger firms, but that the reverse is not true. Consequently, he argues, small firms can never (in the long run) earn higher profit rates than big firms. The author then proceeds to add the following qualifications: (*a*) That large firms may find difficulty in expanding their share of the market (though these difficulties will, of course, be considerably reduced if the industry as a whole is expanding), such "market imperfections" tending to reduce the rate of profit as firms grow larger; (*b*) the possibility of monopolistic or oligopolistic domination of the market; and (*c*) the prohibitive cost of borrowing long-term capital by small firms, which have to rely on the more costly method of borrowing short-term. The last two factors tend to increase the rate of profit of large firms relatively to small firms.

The author then assumes as the basis of his further argument that the economies of large scale

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outweigh the effects of the other factors mentioned, so that the proportion of costs to sales falls as the size of firm increases. Now this is not necessarily true as a proposition of general validity, though it may be applicable in certain trades. In particular, diseconomies—especially those due to the cost of organizing a large-scale business—set in after a certain size is reached, and may outweigh the effects of any further extension of the scale of production. Moreover, the particular relationships existing at any time between the different firms in a given industry are the result of a specific historical development, and cannot be explained without reference to that development.

Continuing his argument, Mr. Steindl (in the chapter on "The Problem of Capital Intensity," which is really the crux of the book) produces various U.S. statistics (taken from *Statistics of Income*) to show that as the average size of U.S. manufacturing corporations increases, so does the ratio of capital assets to gross sales. Mr. Steindl argues that this necessarily implies that *capital-intensity* (defined as the ratio of capital assets to output capacity) also increases with size, since (*a*) size is "necessarily inseparable from capital intensification," and (*b*) the "degree of capacity use will tend to decrease somewhat" as size increases. Consequently, he argues, as size grows the capital invested must also grow. This is, however, counterbalanced by cost-reductions due to the principle of asymmetry mentioned above, and Mr. Steindl shows that the *rate* of profit will increase with size if the *proportionate* reduction in the ratio of cost to sales, consequent on an increase in size, divided by the profit margin, exceeds the *proportionate* increase in the ratio of capital to sales. Assuming, however, that there are "diminishing returns" to capital, the author further shows that the rate of profit normally falls after a certain size is reached. The results of Crum's investigation ("Corporate Size and Earning Power") are then quoted to prove the theory.

While admiring the way in which Mr. Steindl has adapted and—no doubt—improved this aspect of economic theory to fit the statistics as they have been presented by the American authorities, the reviewer feels some doubt both as to the meaning of the concept of capital-intensity as used in this book, and as to the reliability of the statistics themselves as a basis for economic theory.

The only common-sense meaning of capital-intensification is that a firm uses more "capital" *per worker*. But the additional capital will normally be installed only if it results in a greater *output per worker*. Consequently, if the relative increase in productivity per worker is greater than the relative increase in capital per worker, there has been a *decrease* in "capital-intensity" in Mr. Steindl's sense. Conversely, "capital-intensity" can increase simply by a reduction in productivity.

For some independent verification of the thesis that capital-intensity (as defined by Mr. Steindl) increases with size of firm, the reviewer turned naturally to Census of Production data.

The Canadian Census appears to be the only one which cross-classifies size (of establishment) with capital assets and gross output. The data published in the Canadian Report for 1937 (the year for which Mr. Steindl quotes from *Statistics of Income*) relate to 25 of the principal manufacturing industries of Canada, and an analysis shows that no unique general relationship exists between size (of establishment) and the ratio of capital to gross output; for six industries there was a negative relationship, in two the ratio first decreased and then increased with size, while in one the reverse was true.

How can one reconcile these results with those derived from *Statistics of Income?* It is undoubtedly true (as Mr. Steindl himself remarks, p. 25) that the bigger firms would be more integrated vertically and so have smaller *recorded* sales in relation to their capital. It is also true that the bigger corporations hold securities of other big corporations, thus inflating the *recorded* figures of total assets. However, these qualifications by no means bridge the gap. The true reason, so the reviewer believes, is the definition of "size." Whereas all the U.S. statistics quoted by Mr. Steindl refer to a classification by size of *capital assets*, the Canadian Census data refer to size as measured by *gross output*. Actually, the Canadian classification was changed in 1941 to refer to size as measured by *employment*, and the overall results were not greatly different from those on the gross output basis.

This raises the second point mentioned above, viz., the reliability of the basic statistics now available. The classification by *size of capital assets* is used both in the *Statistics of Income* and in Crum's book, and is still being used in the articles on this subject in the *Survey of Current Business*. Why, then, does "capital-intensity" rise with size of firm as measured by capital? There are two reasons : (*a*) The relationship between capital and $\frac{\text{capital}}{\text{output}}$ is nothing more than a relationship between capital and output pure and simple; the results depend entirely (apart from valuation problems) on the effects on productivity of the change in capital, and (*b*) the basis of valuation of capital is itself unreliable. This latter is the most fundamental point. All the U.S. capital figures are "book values" and cannot be used meaningfully in an economic analysis. The same quantum of fixed capital, or its equivalent, may figure at greatly different values in the

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books of different corporations. This effect is magnified on a huge scale by the cyclical swings in the price levels of fixed capital and other assets. Thus corporation A established, say, in 1933, would have a much smaller book-value of assets than corporation B established, say, in 1929, when prices were at their peak, even though the physical assets of each corporation were identical. Corporation A would be classified as a "small" firm with a low capital-intensity, while corporation B would be a "medium" or "big" firm, with high capital-intensity !

There are other aspects of the theory which Mr. Steindl enlarges upon which are extremely important. Again quoting Crum, he shows that if we separate corporations into (1) those making profits, and (2) those making losses, in the first group the *rate of profit* falls as the size of corporation increases, whereas in the latter the *rate of loss* falls as size increases. Mr. Steindl has an elegant and interesting mathematical argument to explain this, in so far as the profit (or loss) is related to equity. If profit is related to total assets, the same general relationships hold, and the author explains this partly by the "fact" that small firms have small capital; consequently, with a given *amount* of profit (or loss), their *rate* of profit (or loss) greatly exceeds that of larger firms. But cannot this "fact" also be explained, at any rate in part, by the method of classification by size ?

There is also an interesting discussion of the measurement of efficiency, in which the author concludes that it is "a quite hopeless, and indeed nonsensical, undertaking to take account of the cost of capital" in the measurement of efficiency, since (*a*) neither the rate of interest nor the rate of profit are connected with scarcity of capital, and (*b*) there is no scarcity of capital in a normal peace-time world. Surely the author would agree that the "cost" of capital is very relevant to present-day practical economics and to a successful full employment policy ?

One would also wish that the author had brought the "degree of monopoly" more directly into the framework of his theoretical system. He rightly stresses its importance as a qualifying factor, but it is really more than this; it is part and parcel of the fabric of modern industry, and should have been included in some form in the general mathematical formulae presented.

The defects in the structure and presentation of the statistics now available to us emphasize the need for further research into these problems, as well as the need for statistics on a more reliable basis. This book is a landmark in the adaptation of economic theory to statistical data, and can prove of very great value not only to workers in this field, but to the whole approach made by economic theorists generally.

A. M.

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STATISTICAL NOTES

(1) British Official Statistics

The interim index of retail prices compiled by the Ministry of Labour and National Service showed little change till mid-November, when it rose from 101 to 103 in consequence of increased prices for sugar, fresh vegetables, and apples, and for alcoholic drink following the raising of the duties. The detailed figures for each month since the index started are as follows:

(Prices at June 17, 1947 = 100)

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Drink and Tobacco*	*Total*
Weights	348	88	97	65	71	35	79	217	1,000
July 15, 1947	101.2	100.0	101.5	100.1	101.7	100.6	100.1	100.0	101
Aug. 12, ,,	99.4	100.0	101.6	100.0	102.6	100.7	100.2	100.0	100
Sept. 16 ,,	99.6	100.0	101.3	103.6	102.4	105.0	100.5	100.0	101
Oct. 14, ,,	100.6	100.1	101.6	106.1	103.1	105.4	102.1	100.0	103
Nov. 18, ,,	103.2	100.1	102.1	106.9	104.0	109.0	102.2	104.0	101
Dec. 16, ,,	103.4	100.1	102.4	107.1	106.3	109.2	102.5	104.1	104
Jan. 13, 1948	103.6	100.1	102.7	109.2	107.5	111.1	103.5	104.1	104

In publishing the figures the Ministry of Labour states that they are in the form in which they are used in the procedure adopted for calculating the index for all the groups combined, i.e., to the nearest first place of decimals. The decimals are shown only in order that, if desired, calculations can be made of the effect of combining particular groups and excluding others. The information available as to price changes, however, is such that no precise significance can be attributed to the decimals, and for any other purposes, therefore, the figures should be used to the nearest whole number.

The principal feature of the recent statistics relating to the total working population was the substantial increase (67,000) in October (the first month of operation of the Control of Engagement Order), followed by a further increase (25,000) in November and a decrease (33,000) in December attributed to postponed retirement of women. The estimated numbers in civil employment showed an even greater proportionate increase (94,000 in October and 48,000 in November) followed by a decrease (22,000) in December. In manufacturing industries there were increases of 75,000 in October and 34,000 in November. The following table shows the figures since August, 1947, together with those for mid-1939 and mid-1945:

Thousands

	Total Working Population (excluding indoor private domestic service)			*Numbers in Civil Employment.**		
	Men	*Women*	*Total*	*Men*	*Women*	*Total*
Mid-1939	14,656	5,094	19,750	13,163	4,837	18,000
Mid-1945	14,881	6,768	21,649	10,133	6,283	16,416
Aug. 1947	14,624	5,719	20,343	13,130	5,594	18,724
Sept. ,,	14,625	5,739	20,364	13,156	5,611	18,767
Oct. ,,	14,641	5,790	20,431	13,200	5,661	18,861
Nov. ,,	14,645	5,811	20,456	13,225	5,684	18,909
Dec. ,,	14,659	5,764	20,423	13,252	5,635	18,887

* Including N.F.S., Police and Civil Defence.

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The level of unemployment, which had gradually fallen after the fuel crisis, reached its lowest point in September. The following three months showed an increase of about 30,000. The figure at December, however, was much lower than a year previously. The following are the statistics from August to the end of the year:

Number of Unemployed Persons on the Registers of the Employment Exchanges of the Ministry of Labour and National Service at the Undermentioned Dates

Date	Insured Unemployed			Total (Insured and Uninsured)
	Men and Boys	Women and Girls	Total	
Aug. 11, 1947	186,204	63,487	249,691	262,787
Sept. 15, ,,	176,811	63,101	239,912	254,009
Oct. 13, ,,	189,336	69,649	258,985	274,817
Nov. 10, ,,	194,723	73,062	267,785	282,283
Dec. 8, ,,	204,305	72,940	277,245	288,515
Jan. 12, 1948	238,566	79,681	318,247	331,477
Jan. 13, 1947	301,928	99,321	401,249	415,770

The total for January, 1948, includes 38,668 married women and 9,023 ex-Service personnel who had had no employment since leaving the Forces. The 13,230 uninsured persons on the register at January 12 included 2,000 boys and girls under 18 who had not yet entered industry. The totals prior to January, 1948, do not include men and women on the register who were classified as unsuitable for ordinary employment. The system of classification was terminated, however, at the end of 1947, and the figures for January include about 8,000 workers who had been excluded in December. The figures still exclude registered disabled persons who are suitable only for sheltered employment.

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(2) Other Statistics

In his annual figures of Statistics of Failures in the United Kingdom and Ireland for the year 1947, Mr. Richard Seyd gives a total of 850 failures (740 bankruptcies and 110 deeds of arrangement, including Scottish Trust Deeds), compared with totals of 420 in 1946 and 329 in 1945. In the financial, wholesale and manufacturing trades the total number of failures in 1947 was 92 (80 bankruptcies and 12 deeds of arrangement) compared with 45 (40 bankruptcies and 5 deeds of arrangement) in 1946; in the professional classes there were 148 (145 bankruptcies and 3 deeds of arrangement) compared with 107 (105 bankruptcies and 2 deeds of arrangement) in 1946; and in the retail trades and working classes, 610 (515 bankruptcies and 95 deeds of arrangement) compared with 268 (232 bankruptcies and 36 deeds of arrangement) in 1946. The 1947 totals include 12 (2 wholesale and 10 retail) in Eire.

During the year 2,186 Limited Companies were wound up (1,980 English, 157 Scottish, 17 in Northern Ireland, and 32 in Eire). Of these, 143 (4 in Eire) were on account of liabilities, 113 in the financial, wholesale and manufacturing trades, 10 in the professional classes and 20 in the retail trades. The number of failures of private persons was 82 in 1947, compared with 61 in 1946 and 55 in 1945. In the retail trades builders showed the highest number of failures, 117 compared with 32 in 1946; plumbers, painters and gas fitters came second with 68 (compared with 16 in 1946); and farmers third with 49 (compared with 26 in 1946).

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CURRENT NOTES

During the first fortnight in May Mr. L. H. C. Tippett is to give ten lectures at the Massachusetts Institute of Technology, Cambridge, Massachusetts. The first five will be on Statistical Methods for Industrial Quality Control, and the subjects dealt with will include: the specification of quality by statistical measures—frequency distributions, averages, measures of variation, percentages defective; the relation between tolerances and the percentage defective; control charts, their construction and interpretation—percentage defective, average, range, special adaptations; sampling schemes—single sampling, double sampling, sequential sampling. Emphasis will be laid on the rationale of quality control.

The second series, on Statistical Methods for Technical Investigation and Experimentation, will be devoted to the treatment of experimental and observational errors by statistical sampling theory, tests of significance, the design of investigations and experiments, including those involving the statistical methods of correlation analysis and the analysis of variance. Illustrations will be taken from the factory and laboratory.

On May 14th, the day of Mr. Tippett's final lecture, Dr. Walter A. Shewhart, of the Bell Telephone Laboratories, will speak at a dinner meeting on the Future of Statistics in Industrial Research and Quality Control.

The Statistical Office of Czechoslovakia will be, we think, the first of such institutions to make its work known through the cinema when it releases, as it hopes soon to do, the short film "Zivot a ciala," or Life and Numbers. This shows the work of the Office, and demonstrates the importance of Statistics for the various kinds of industry, and indeed of all sections of the nation's life.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

The Banker—

November 1947—Banks and the export drive: I—Scope of advisory services: *Service Etranger*. Scotland—a financial and economic survey: articles by *The Rt. Hon. Walter Elliot, M.P., G. B. Primrose, F. W. Forge, W. Irvin* and *A Special Correspondent*.

Economica—

August 1947—Cheap money policy: *F. W. Paish*. Economic progress in a stable environment: *A. C. Pigou*. The origin of the monopoly of broadcasting in Great Britain: *R. H. Coase*. A note on profit and uncertainty: *F. H. Hahn*.

November 1947—In memory of Sidney Webb: *R. H. Tawney*. The distribution of incomes: *F. A. Cockfield*. A reconsideration of the theory of effective demand: *T. Wilson*. Comparative shipping and shipbuilding costs: *R. O. Roberts*.

Economic Journal—

March 1947—John Maynard Keynes, 1883–1946: *E. A. G. Robinson*. Britain's foreign trade problem: *G. D. A. Macdougall*.

June 1947—World recovery after war—a theoretical analysis: *J. R. Hicks*. Dollar scarcity: some remarks inspired by Lord Keynes' last article: *S. E. Harris*. The economic position of the Domesday sokemen: *Reginald Lennard*.

Eugenics Review—

January 1947—Galton on eugenics as science and practice: *C. P. Blacker*.

October 1947—Stages in population growth: *C. P. Blacker*. The measurement of socially valuable qualities: *H. J. Eysenck*.

Heredity—

July 1947—Genetic research in Britain, 1939–1945: a summary by various workers. A bibliography of genetic research published in Italy and Germany, 1939–1945: *A. Buzzati-Traverso*. A directional change in the genetic constitution of a natural population of *Drosophila pseudo-obscura: Th. Dobzhansky*. Methods of analysing the virulence of bacteria and viruses for genetical purposes: *L. L. Cavalli* and *C. Magni*. Undulated: a new genetic factor in *Musmusculus* affecting the spine and tail: *M. E. Wright*.

Institute of Actuaries, Journal—

June 1947—Presidential address: *A. H. Rowell*. Report of the Cohen Committee on Company Law Amendment: Abstract of discussion. An analysis of a pension fund: *W. F. Marples*. Alfred Watson Memorial Lecture: The value of the actuary in general statistical and administrative work: *Sir William V. Wood*.

Manchester School of Economic and Social Studies—

September 1947—The pricings of public utility undertakings: *A. M. Henderson*. The compilation of location: *M. P. Fogarty*. A note on the visual representation of national income statistics: *R. J. Loosmore*.

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Oxford University Institute of Statistics, Bulletin—

June 1947—Feeding a family: *T. Schulz.* Notes on some balance of payments figures: *A. R. Conan.*

July 1947—The problem of the British balance of payments: *T. Balogh.* The 1947 National Income White Paper: *D. Seers.*

August 1947—Consumption of groceries and rationing: *T. Schulz.* The implications of the Marshall speech: *H. D. Henderson.*

September 1947—Strikes and their changing economic context: *K. C. G. Knowles.* Post-war development of Sweden's foreign trade: *Gustav Cedarwall.*

October 1947—Bulk purchasing and the colonial producer: *P. Ady.* Coal developments, 1946–7: *D. Seers.* Some comparisons of pre-war and post-war productivity: *P. D. Henderson.*

Review of Economic Studies—

Vol. XIII, No. 34—International comparison of demand for imports: *Tse Chun Chang.* The generalised theory of consumer's surplus: *J. R. Hicks.* Rationing and value theory: *H. Makower.* Migration and the distributive trades: *Sarah C. Gillespie* and *K. W. Rothschild.* Rebuilding London—a survey in Stepney, 1946: *T. Barna.*

Vol. XIV, No. 35—A revolution in economic theory?: *C. Kaysen.* Distribution methods and costs in the U.S.A.: *R. Evely.* Short notes on a model of the trade cycle: *V. Marrama.*

Transactions of the Manchester Statistical Society—

Session 1946–47—Cotton's war effort: *R. W. Lacey.* The cotton trade's war-time commodity supplies: *W. Hubball.* Some problems of taking a census of distribution: *W. B. Reddaway.* Some aspects of the growth of secondary school examinations: *J. A. Petch.* Statistics In Medicine: *Prof. A. Bradford Hill.*

UNION OF SOUTH AFRICA—

South African Journal of Economics—

June 1947—Methodological issues in the theory of price flexibility: *D. G. Franszen.* Gif fredome failye: *R. Leslie.* Konjunktuurgevoeligheid van Suid-Afrikaanse belastings: *J. L. Sadie.*

UNITED STATES—

American Academy of Political and Social Science, Annals—

July 1947—Progress and prospects of the United Nations. (Whole number.)

September 1947—Features of present-day Canada. (Whole number.)

American Economic Review—

June 1947—The disequilibrium system: *J. K. Galbraith.* Federal reserve objectives and policies: *E. A. Goldenweiser.* The ITO charter: *R. F. Mikesell.*

September 1947—Forecasting a multilateral balance: *Ragnar Frisch.* Cost functions and full employment: *A. H. Hansen.* Trade unions as wage-fixing institutions: *A. M. Ross.* Exchange rate determination: *J. P. Young.* Burden of import duties with fixed exchange rates: *E. R. Rolph.*

American Statistical Association, Journal—

June 1947—Recent productivity trends and their implications: *W. D. Evans.* The best unbiased estimate of population standard deviation based on group ranges: *F. E. Grubbs* and *C. L. Weaver.* Interest rates by loan size and geographical region: *John M. Hartwell, Jr.* "Cost-utility" as a measure of the efficiency of a test: *J. Berkson.* New indexes of hourly and weekly earnings compiled by the Federal Reserve Bank of New York: *G. Garvy* and *R. E. Lewis.* Farm employment levels in relation to supply and demand as per cent. of normal: *W. A. Hendricks.* The use of the angular transformation in biological assays: *Lila F. Knudsen* and *J. M. Curtis.* The problem of plot size in large-scale yield surveys: *P. V. Sukhatme.* Irving Fisher 1867–1947: *W. L. Thorp.*

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Annals of Mathematical Statistics—

June 1947—Problems in probability theory: *H. Cramér.* The estimation of dispersion from differences: *A. P. Morse* and *F. E. Grubbs.* The efficiency of sequential estimates and Wald's equation for sequential processes: *J. Wolfowitz.* Estimation of linear functions of cell proportions: *J. H. Smith.* A statistical problem connected with the counting of radioactive particles: *Sten Malmquist.* The probability function of the product of two normally distributed variables: *L. A. Aroian.* A remark on characteristic functions: *A. Zygmund.* A lower bound for the variance of some unbiased sequential estimates: *D. Blackwell* and *M. A. Girschick.* An extension to two populations of an analogue of Student's *t*-test using the sample range: *J. E. Walsh.* On the norm of a matrix: *A. H. Bowker.* Definition of the probable deviation: *M. Fréchet.* The general relation between the mean and mode for a discontinuous variate: *M. Fréchet.* Note on differentiation under the expectation sign in the fundamental identity of sequential analysis: *T. E. Harris.* A uniqueness theorem for unbiased sequential binomial estimation: *L. J. Savage.*

September 1947—On the asymptotic distribution of differentiable statistical functions: *R. V. Mises.* Approximate solutions for means and variances in a certain class of box problems: *P. J. McCarthy.* The distribution of the range: *E. J. Gumbel.* Low moments for small samples: a comparative study of order statistics: *C. Hastings, Jr., F. Mosteller, J. W. Tukey* and *C. P. Winsor.* Sequential confidence intervals for the mean of a normal distribution with known variance: *C. Stein* and *A. Wald.* A useful convergence theorem for probability distributions: *Henry Scheffé.* An explicit representation of a stationary Gaussian process: *M. Kac* and *A. J. F. Siegert.* Approximate formulas for the radii of circles which include a specified fraction of a normal bivariate distribution: *E. N. Oberg.* A note on the efficiency of the Wald sequential test: *Edward Paulson.* A note on the Poisson-Charlier functions: *C. Truesdell.*

Biometrics—

September 1947—The development and use of statistical practices in hospital work: *P. M. Densen.* Probability tables for individual comparisons by ranking methods: *Frank Wilcoxon.* Treatment of the fourfold table by partial association and partial correlation as it relates to public health problems: *H. L. Lombard* and *C. R. Doering.* Time-specific life tables contrasted with observed survivorship: *Margaret Merrell.*

Econometrica—

July 1947—Dynamic coupling with especial reference to markets having production lags: *R. M. Godwin.* La distribution du revenu entre les divers biens: *René Roy.* The general elasticity of demand: *H. B. Woolley.* Note on a light plant's cost curves: *J. A. Nordin.* Some problems arising in estimating economic relations: *L. Hurwicz.* A note on a maximum-likelihood estimate: *T. W. Anderson.* Note on a problem of Ragnar Frisch: *C. R. Rao.*

Harvard Business Review—

Summer Number 1947—Outlets for life insurance investment: *Stahrl Edmunds.* Psychology in market research: *E. Dichter.* Our international aviation policy: *R. R. Hackford.* Trade association practices and anti-trust law: *J. S. Hays* and *J. L. Ratzkin.*

Journal of Experimental Education—

June 1947—Opinion toward education in Montreal, Canada: *W. D. Blum.* Characteristic limitations of the internal tuning of selected wind instruments as played by amateurs: *A. W. Ahrens.* A study of some means of presenting information to parents about the school health problem: *F. V. Hein.* On a class of interpolation functions for system of grading: *E. F. Cox.*

Journal of Political Economy—

June 1947—Public policy in labor disputes: the crisis of 1946: *O. W. Phelps.* Average cost and long-run elasticity of demand: *H. M. Oliver, Jr.* Volume of savings, quantity of money, and business instability: *Clark Warburton.* Measuring state tax burden: *A. S. Donnahoe.*

August 1947—Burns and Mitchell on business cycles: *E. S. Shaw.* Intricacies of Russian national-income indexes: *Naum Jasny.* Worker response and social background: *Melville Dalton.* Measuring state and regional business cycles: *Rutledge Vining.* The effect of replacement and investment on national income and employment: *S. P. Dobrovolsky.*

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Mathematical Tables and other Aids to Computation—

July 1947—Admiralty computing service.

Milbank Memorial Fund Quarterly—

July 1947—Nutrition in war and peace: *F. G. Boudreau.* Wartime shifts of the civilian population: *H. S. Shryock, Jr.* Special problems of negro migration during the war: *Ira de A. Reid.* Projection of urban growth and migration to cities in the United States: *P. M. Hauser* and *H. T. Eldridge.*

Quarterly Journal of Economics—

August 1947—Collective bargaining by air-line pilots: *H. Northrup.* Small-scale industry in Japan: *E. Reubens.*

Review of Economic Statistics—

August 1947—The problem of wage policy in the spring of 1947: *S. H. Slichter.* Exchange depreciation and international monetary stability: *J. J. Polak.* Farm family budgets—a moving picture: *W. W. Cochrane.* Wholesale prices and industrial stock prices during and immediately after the two world wars: *L. H. Bean.*

BELGIUM—

Bulletin de l'Institut de Recherches Economiques et Sociales—

June 1947—Chronique de la conjoncture économique de la Belgique: *Yves Urbain.* Conjoncture et politique économique aux Etats-Unis: *Roger Dehem.* Les finances publiques belges: *A. E. Janssen.* Les finances privées: *Charles Roger.* Le mouvement social en 1946: *André Woronoff.*

July 1947—L'Avenir de notre production de houille: *C. D. de Lespaul.* La métallurgie belge en 1946: *R. de Strycker.* L'Industrie textile en 1946: *Carlos Haustrate.* La construction: *Alphonse Vasanne.* Les industries diverses en 1946: *Jean Colard.* Prix, consommation et revenue national: *Fernand Haudhuin.* Le commerce extérieur de la Belgique: *Jean Jussiant.* L'évolution de l'agriculture belge en 1946: *Gilbert Mullie.* Les transports intérieurs: *Yves Urbain.*

CZECHOSLOVAKIA—

Statistický Obzor—(Czech text, Russian, English and French summaries).

Vol. XXVII, Part II—The present increase of fertility in Bohemia, Moravia and Silesia: *Jaromir Korčák.* Measuring test reliability: *Karel Tříska.* Problem of weight in calculating indices of cost of living: *Jan Mach.*

DENMARK—

Nationaløkonomisk Tidsskrift—

Hefte 1–2, 1947—Staten, Erhvervslivet og Forbrugerne: *Ebbe Groes.* Industrien og Rationalisering: *H. P. Christensen.* Dansk Importregulering gennem 15 Aar: *Ester Boserup.*

FRANCE—

Journal de la Société de Statistique de Paris—

July-August 1947—Recherche sur les unités de mesure d'un "nouveau contrat social": *M. Jarry.* Sur les expressions analytiques de la mortalité valables pour la vie entière: *M. Frechet.* Échange de vues sur les réformes à apporter a l'étude des mathématiques dans l'enseignement moyen: Chronique des statistiques agricoles: *M. Augé-Laribé.*

Population—

July-September 1947—Faits et problèmes du jour: *A. Sauvy.* Comment déterminer la tendance de la fécondité? *Paul Vincent.* Remarques sur les doctrines de la population depuis deux siècles: *J. Bourdon.* Mouvements migratoires d'après guerre: *J. Doublet.* Résultats d'une enquête préliminaire sur l'avortement dans la région parisienne: *J. Sutter.* Politique sociale et démographique en Suisse: *A. Michot.*

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Revue d'Économie Politique—

May–June 1947—La querelle des classiques et des modernes: *G. Lutfalla.* A propos de la "théorie générale" de Lord Keynes: *G. Ardant.* De l'incidence des doctrines sur la pratique comptable: *C. Penglaou.* Revenue national: *J. Dumontier.* Richesse et bien-être dans l'économique anglo-américaine: *J. Valarché.*

MEXICO—

Estadística—

September 1947—First session of the Inter-American Statistical Institute. Concept of a national focal point for international statistics: *H. L. Dunn.* Un mundo estadistíco: *Earl Latham.* Costos de los censos en diez naciones americanas: *G. Jardim.* Metodología de las prácticas estadísticas del comercio exterior en las Americanas (extractos): *S. Wosco-boinik.*

SWEDEN—

Ekonomisk Tidskrift—

September 1947—The use of correlation analysis in economic research: *J. Tinbergen.* Pris-bildningsteorin och konsumtionsföreningarnas prispolitik: *Av Arnolds P. Aizsilnieks.* Jordbrukets strukturutveckling: *Av Yngve Berggren.*

INTERNATIONAL—

International Labour Review—

June 1947—Post-war manpower problems in Europe. The social and economic role of engineers and technicians: *J. H. E. Fried.* The importance of medical statistics in social insurance: *N. Marx.*

Revue de l'Institut International de Statistique—

1946—Comment remédier à la signification indéterminée des indices statistiques traditionnels (avec résumé anglais): *G. Hostelet.* Dégager les possibilités et les limites d'application des sciences mathématiques (et en particulier du calcul des probabilités) à l'étude des phéno-menès économiques et sociaux (première enquête scientifique): *R. M. Frechet.* Dévelop-ment of statistics in the United Kingdom (avec résumé français): *A. L. Bowley.*

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Vol. CX.] [Part IV.

Journal of the Royal Statistical Society

PART IV, 1947

The Iron and Steel Development Plan: Some Statistical Considerations

By Robert M. Shone

[Read before the Royal Statistical Society, May 22nd, 1947, Dr. E. C. Snow, C.B.E., in the Chair]

Introduction

In looking through the previous Papers read to the Society, I see that there have been only two in the last 25 years wholly devoted to iron and steel. These were given by the late Mr. M. S. Birkett in 1920 and 1932. The first was of considerable interest in covering the main statistics of the 1914–1918 war. The second surveyed the development of the industry from 1920 to 1932.

At the present time it is hardly necessary to follow Mr. Birkett's lead and cover the wartime figures, as these have already been issued as part of the regular publication of steel statistics.* Indeed, I shall not attempt, as in the past Papers, to deal mainly with historical matters, but to cover the statistics which bear particularly on the future development of the steel industry.

At the outset there are three general observations regarding this Paper which I should make. The first is that any statistical discussion of the Steel Development Plan must necessarily over-simplify the issues involved. The steel industry is part of the range of productive processes intermediate between the mining of ore and coal and the production of a vast range of industrial products containing steel or made with steel equipment. The stage at which steelmaking is separate from fabrication of steel does not come at any point which can be determined by a simple theoretical or practical rule. It is desirable to carry forward the processing and manipulation of steel to enable the gases from the blast furnaces and coke ovens to be used for power and other purposes, to save carriage, and to adjust more accurately the molten steel to the qualities of tubes, bolts and nuts, girders, forgings, castings, etc., required by the using industries. But there are also advantages in having the making of these products closely geared in with the engineering and processing trades, so that their special requirements can be met. The structure of the steel industry, therefore, is necessarily complex and varied. It must also be flexible to meet varying demands for all the shapes, sizes and qualities of alloy and carbon steels. Yet, with all this variety, the maximum degree of large scale mass production must be achieved if the economies peculiar to large integrated plants are to be realized.

A second class of factors must be ignored if this Paper is to be kept to manageable size. They are all the local considerations of sites, water supplies, road and rail construction, and the countless other practical points which must be constantly in mind in planning specific developments. Indeed, any general plan, such as the Steel Development Plan, aims essentially at bringing together the aspects of development which, on the one hand, are of significance in relation to the general industrial development of the country, and, on the other, provide a framework within which the practical issues of particular local developments can be formulated and tested.

The third point I wish to make is that many of the statistics used and quoted here are necessarily very broad approximations. I have deliberately not burdened this Paper with a great deal of valuable information which is available regarding steel, as this is published as a matter of regular

* *Statistics of the Iron and Steel Industry of the U.K.*, volume for 1939–44, volume for 1945, also *Monthly Statistical Bulletin*, which resumed publication in January, 1946; all published by the British Iron and Steel Federation.

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TABLE 1

Steel Production, Imports, Exports and Home Deliveries: U.K., 1900–1946. (*Thousand Ingot Tons*)

	Production.	Imports.	Exports.	Home deliveries.*
1900	4,901	443	1,619	3,725
1	4,904	548	1,759	3,693
2	4,909	503	2,139	3,273
3	5,034	986	2,629	3,391
4	5,027	1,100	2,643	3,484
1905	5,812	1,183	3,061	3,934
6	6 462	1,177	3,296	4,343
7	6,523	849	3,483	3,889
8	5,296	1,119	3,107	3,308
9	5,882	1,138	3,501	3,519
1910	6,374	1,343	3,764	3,953
1	6,462	1,720	3,702	4,480
2	6,796	1,962	3,941	4,817
3	7,664	2,083	3,744	6,003
4	7,835	1,422	3,375	5,882
1915	8,550	1,010	2,923	6,637
6	8,992	587	2,658	6,921
7	9,717	369	1,826	8,260
8	9,539	244	1,274	8,509
9	7,894	374	2,147	6,121
1920	9,067	988	3,247	6,808
1	3,703	1,463	1,694	3,472
2	5,881	786	3,391	3,276
3	8,482	1,180	4,310	5,352
4	8,201	2,168	3,844	6,525
1925	7,385	2,586	3,357	6,614
6	3,596	3,552	2,689	4,459
7	9,097	4,187	3,776	9,508
8	8,520	2,753	3,834	7,439
9	9,636	2,682	3,941	8,377
1930	7,326	2,821	2,920	7,227
1	5,203	2,756	1,828	6,131
2	5,261	1,544	1,743	5,062
3	7,024	940	1,775	6,189
4	8,850	1,323	2,078	8,095
1935	9,859	1,193	2,501	8,551
6	11,785	1,325	2,345	10,765
7	12,984	1,483	2,921	11,621
8	10,398	975	1,985	9,238
9	13,221	1,525	1,735	12,811
1940	12,975	3,356	1,286	13,945
1	12,312	3,658	526	14,038
2	12,942	2,407	274	15,682
3	13,031	2,773	122	15,883
4	12,142	1,668	240	14,088
1945	11,820	173	674	11,882
6	12,693	487	2,508	11,132

* Allowing for stock changes from 1937.

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course. In the main I have given figures which are more difficult to arrive at accurately, but which it is essential to attempt to assess in some quantitative form in considering future plans.

The Paper will fall into three main sections, all concerned with different aspects of the Steel Development Plan. The first sets out some of the information bearing on the estimation of the future demand for steel; the second deals in the main with the estimation of future supplies of scrap; and the third describes the progress made in implementing the Plan since it was considered by the Government a year ago.

I. Demand for Steel

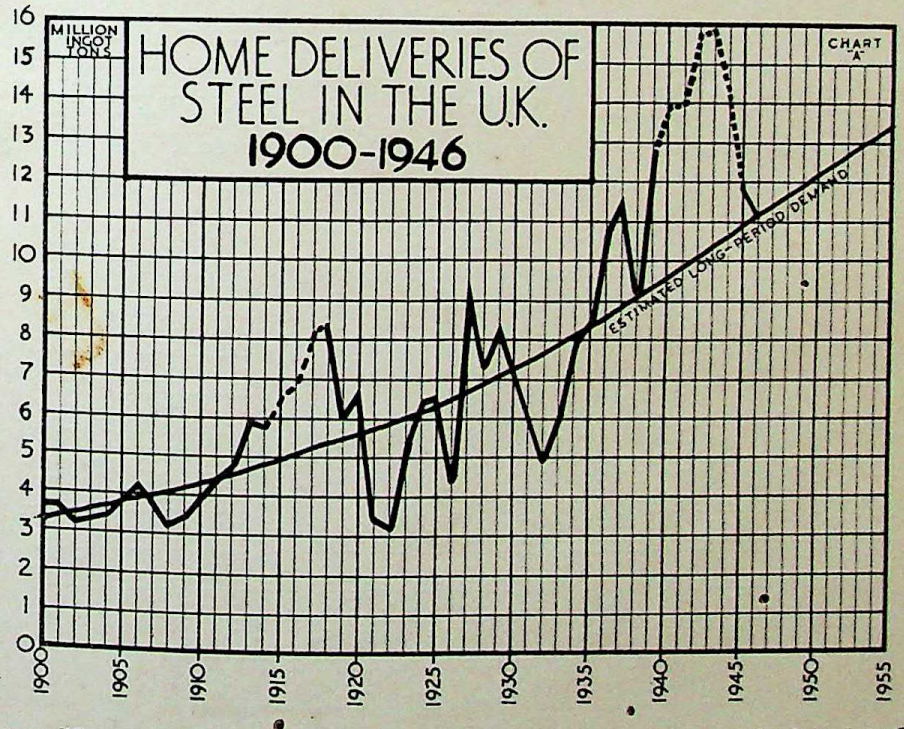
Approximate estimates of the probable future demand for steel were given in the industry's Development Plan which was published as a White Paper.* These formed the basis of the future capacity of the industry which was aimed at in the Plan. The total demand in the five years 1950–1955 was estimated to reach 16 million ingot tons a year, consisting of 13 million tons for home requirements and 3 million tons for direct export. The former figure of course includes the steel going into manufactured products for export. The broad basis of these figures was given in the White Paper, but fuller information may usefully be given on certain points taken into consideration in arriving at the estimates.

Long Term Trend

The figure of 13 million ingot tons for home requirements was supported by the long period trend of home deliveries of steel prior to the war. The annual figures of home deliveries between 1900 and 1946 are shown in Table 1.

Although there were wide fluctuations from year to year, it will be seen that there was a strong upward movement during the period. The figures which have been plotted in Chart A bring this out clearly. A free-hand trend line has been drawn on the Chart, and if this is projected

CHART A



* *Iron and Steel Industry*, reports by the British Iron and Steel Federation and the Joint Iron Council, Cmd. 6811.

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forward without taking account of either of the two wars, it gives a figure of about 13 million ingot tons as the estimated annual requirement in the period 1950–1955.

The sharply rising trend in the quantity of steel used in this country is related to the industrial development of the period 1900 to 1946. The increase in the use of machinery in industry and agriculture, the growth of mechanical equipment in offices and the home, the rising volume of transport, the rapid development of the private car, and the great expansion in electrical generation and distribution—all these factors combined to increase the use of steel.

Since this kind of development was common to most industrial countries, it is not surprising that the upward movement of steel consumption per head of the population is repeated in other principal industrial countries, as illustrated in Table 2.

TABLE 2

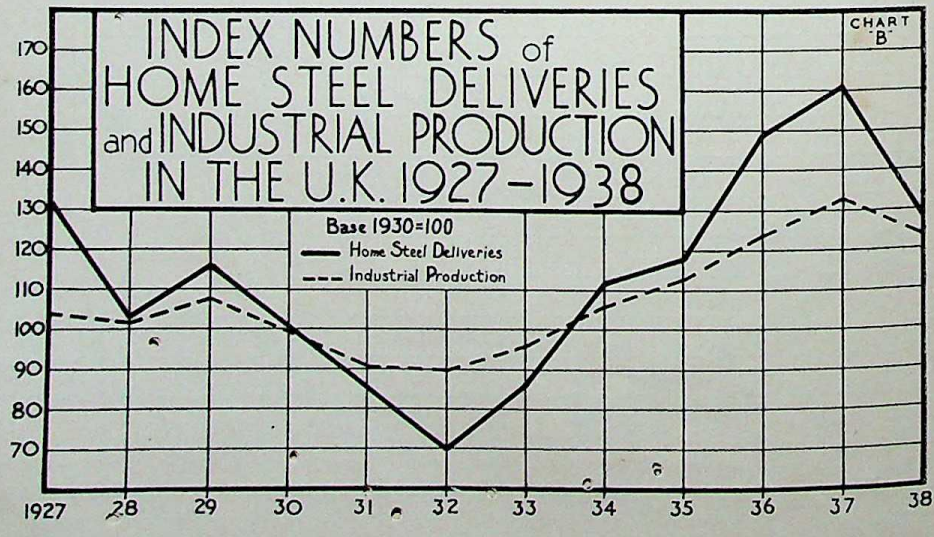
Estimated Steel Consumption per Head of the Population in Certain Countries.* (*Ingot lbs.*)

	1914.	1929.	1932.	1935.	1937.
United Kingdom	307	411	245	409	550
U.S.A.	504	992	242	581	805
Germany†	395	379	132	431	509
France‡	124	414	247	224	300
Belgium-Luxemburg	..	453	249	235	366
U.S.S.R.	..	87	95	184	237
Japan§	44	137	97	162	220

* Steel available for home consumption.
† The figures include the Saar for all years, but otherwise refer to post-1920 frontiers, except for 1914.
‡ Includes Alsace-Lorraine except for 1914.
§ Home islands only.

In view of the preponderance of heavy industry among the consumers of steel, and the fact that the activity of the durable goods industries fluctuates more widely than production as a whole, changes in steel production and consumption before the war had a greater amplitude than the movement of general industrial production. This is shown in Chart B, showing index numbers of steel consumption and the Board of Trade index of industrial production for the years for which it is available—1927 to 1938.

CHART B



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The tendency for fluctuations in the country's economy to be reflected even more violently in steel production has created special difficulties for the steel industry in view of the high ratio of fixed capital to turnover which characterizes the industry.

Consumption by Industries

In considering the future demand for steel an attempt has been made to analyse the steel consumption by the main consuming industries. It has always been difficult to secure reasonably accurate figures on this subject, and before the war no comprehensive information was published. There is, however, a basis for estimating industrial consumption fairly closely in the Census of Production Report for 1935, which gives considerable detail and covers approximately 90% of the total steel deliveries in the U.K. On the basis of these figures and of partial information yielded by the Census of Production for 1924, 1930 and 1937, Table 3 has been drawn up, setting out estimates of steel consumption by the main using industries.

TABLE 3

Estimated Direct Consumption of Steel by Industrial Groups in the U.K. (*Thousand tons.*)

Industry.	1924.	1930.	1935.	1937.
Shipbuilding and marine engineering	925	880	540	840
Building and constructional engineering	670	920	1,375	1,725
Mechanical engineering	780	820	880	1,180
Electrical engineering	100	120	180	235
Motors and cycles	185	270	440	550
Aircraft	2	5	10	25
Railways and railway carriage and wagon building	600	565	610	760
Collieries	200	250	330	360
Hardware and hollow ware	350	500	685	790
Rivets, bolts, nuts, screws, chains, springs and miscellaneous forgings	400	450	510	630
Wire and wire manufactures	300	300	400	500
Other	363	395	540	685
Total finished steel	4,875	5,475	6,500	8,280
Ingot equivalent	6,500	7,300	8,670	11,040

Notes

The estimates for 1935 are, in general, based on data given in the Final Report of the Fifth Census of Production, but with an allowance in respect of firms excluded from the Census enquiry. The estimates for 1924 and 1930 have been calculated on the basis of data published in the 1935 Census Report. For collieries the figures are based on deliveries of colliery arches, girders, etc.

The figure included under "Wire and Wire Manufactures" is an estimate (based on the Census figures) of the quantity of finished materials passed on to the metal-using industries, with an allowance for exports and imports. To avoid double counting, wire and its products are, therefore, excluded from the consumption figures for the separate industries.

The final item, "Other," includes four minor trades covered by the Census enquiry—tools and implements, cutlery, needles, pins, etc., and small arms—as well as an estimate for the following uses: tinplate used by canners making their own cans and by toy makers; direct purchases of steel by gas, water and electricity supply undertakings; tram rails; direct munitions requirements; direct purchases of steel for repair and maintenance work by the steel and other industries, which do not use steel as a raw material, but only for repairs and maintenance.

The figures do not agree with those in Table 1, since they related to deliveries, not consumption.

The steel allocation arrangements instituted during the war and still in operation do not enable reasonably comparable current figures to be obtained for steel consumption on the same industrial basis. These arrangements were originally based on allocations to Government Departments in

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the light of their respective requirements of end-products for war purposes. Table 4 gives the analysis of steel deliveries which arises from the steel distribution scheme for 1944, 1945 and 1946.

TABLE 4

Deliveries of Finished Steel by Authorizing Department, 1944–1946. (*Thousands of Tons*)

Department.	1944.	1945.	1946.
Home Office and Ministry of Home Security	7·7	3·2	3·7
Raid damage	4·8	4·4	1·1
Admiralty	1,322·9	671·7	182·3
,, (Mercantile)	627·2	680·6	946·7
War Office	158·7	125·8	40·8
Ministry of Supply	4,656·8	3,065·4	2,380·9
Air Ministry	68·5	19·1	12·6
Ministry of Aircraft Production	933·2	429·9	68·2
Scottish Departments	15·7	13·6	30·6
Board of Trade	224·6	435·9	748·5
,, ,, (Indirect Export)*	89·1	257·9	331·6
,, ,, (Direct Export)†	122·4	645·8	1,336·0
Ministry of Health	9·0	13·8	163·3
,, of Agriculture and Fisheries	118·9	111·4	142·4
,, of War Transport	589·8	527·8	620·6
,, of Food	283·7	263·7	255·2
,, of Works	238·0	344·1	650·5
General Post Office	27·1	18·9	12·2
Ministry of Fuel and Power (Gas Division)	46·5	60·8	80·1
,, ,, ,, (Coal Division)	550·7	579·8	632·1
,, ,, ,, (Petroleum Division)	110·8	178·3	331·7
Electricity Commissioners	44·3	137·1	170·9
Northern Ireland	19·8	19·4	25·0
	10,270·2	8,608·4	9,166·9
Steel for Exempt Products‡	..	313·1	795·6
Total (including exports)	10,270·2	8,921·5	9,962·5

* *I.e.*, deliveries of finished steel for the manufacture of articles for export not falling within the province of other departments.

† *I.e.*, deliveries of finished steel for export as such under Board of Trade authority. In addition there were export deliveries under other symbols, *e.g.*, P.D., M.F.

‡ The tonnage shown is that delivered for the manufacture of certain products which were removed from acquisition control in 1945. These include rivets, bolts, nuts, springs, wire, reinforcement fabric mesh, wire rod reinforcement, boot and shoe grindery, wire staples and electrical stampings. In 1944 these products were only obtainable against departmental authorization and, therefore, the tonnages of the finished products are included on the deliveries by authorizing Departments for those years.

These post-war figures are difficult to use for forward estimating for various reasons. They include exports under a variety of headings: Part is specifically shown under the Board of Trade B.T.5 heading, but considerable tonnages also fall under various other Departments, particularly as pipe-line for export is recorded against the Petroleum Division of the Ministry of Fuel and Power and an export of tinplate for containers against the Ministry of Food. The figures also suffer from the fact that approximately 30% of the home consumption of steel is authorized by the Ministry of Supply and is shown in one global figure, covering the requirements for motor vehicles, a substantial proportion of mechanical and constructional engineering and many other important steel-using industries, quite apart from munitions and (since the absorption of M.A.P.) aircraft. While the analysis enables small quantities of steel to be tracked down to Departments

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using minor tonnages, it does not separate figures for many of the main consuming industries. A further difficulty in the use of figures on a Departmental basis is that responsibilities as between the Departments periodically change, interrupting the continuity, so that any series on this basis is of limited value for general use.

The records of deliveries of steel against the various authorizations of the Departments are obtained by means of regular returns from steel producers, who analyse all their orders and deliveries against each of the Departments. It would be impracticable to superimpose on this analysis a parallel analysis of deliveries by consuming industries. If the figures are to be of general value it would seem desirable that the classifications under which deliveries are recorded for the Steel Distribution Scheme should be reviewed in order to see whether the arrangements could not be modified to tie in more simply with a natural industrial grouping, and in particular with that adopted for Census of Production purposes, which in future will correspond with the standard industrial classification now being worked out by the Central Statistical Office.

In the case of the American industry, delivery figures are recorded by using industries much on the basis of the classification given in Table 3, though expanded to break down some of the headings. This is done by voluntary agreement between the steel industry and users, as a result of which orders for steel are marked with an industrial classification indicating the purpose for which the steel is used. In cases where the voluntary system breaks down, the steel firms are responsible for coding the orders to the best of their knowledge at the time of receipt. The steel producers there, as in this country, supply regular returns analysing the distribution of steel deliveries.

The whole value of the analysis—at least for the general user of statistics—depends on the choice of a useful and commonly understandable industrial classification, and on maintaining the classification without frequent changes, thus linking the figures with the general body of economic data.

Future Home Requirements

In forecasting the future requirement, it has been found best to consider the probable trend of demand for each of the industries given in Table 3, rather than work on the classification in Table 4. In total, a home requirement of 9¾ million tons of finished steel has been arrived at, or about 13 million ingot tons.

This estimate of 13 million tons compares with deliveries in 1946 of 11,132,000 ingot tons. During the course of 1946, however, as conversion of using industries neared completion, requirements rose, and in the fourth quarter of 1946 steel was being delivered at the rate of 12¾ million ingot tons per annum. There seems little doubt that, with the existing labour force in the metal-using industries, the trend of consumption would have continued upwards during 1947, and over 13 million tons would have been required for home consumption. In part, the high demand envisaged in 1947 is associated with the overtaking of wartime arrears, and may not be a good guide to the more permanent level of steel requirements when these arrears have been worked off.

The year 1937 to some extent was also one in which capital construction was at a peak level and no doubt contained some element of arrears carried over from the previous slump, and, to a limited extent, particularly on the constructional side, showed the early effect of the re-armament programme. Nevertheless, it is probably the best single year on which to base considerations of the future pattern of demand. In relation to 1937 it appears reasonable to estimate increases in mechanical and electrical engineering and in the motor and cycle and the aircraft industries, on the grounds of the contribution which these industries will be required to make in the future to increase exports. In engineering generally increases should also result from the greater mechanization of industry which will be necessary to achieve a higher level of industrial productivity in this country.

Although in certain directions substitutes may well be found for steel, there is also likely, compared with 1937, to be some maintenance of the present substitution of steel for other materials. It is probable, for example, that there will be some permanent increase in the use of steel in substitution for timber pit-props in collieries, and possibly in substitution for wooden sleepers on the railways. Moreover, the development of the use of steel for furniture and office equipment as well as for domestic purposes, including refrigerators and kitchen equipment generally, is

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likely to expand consumption under the hardware and hollow-ware category, as well as to add further to the miscellaneous steel uses. The steady expansion in the use of tinplate for containers is also likely to continue in the future. Ordnance requirements before the war were mainly included under the miscellaneous heading, and some increase, with conscription and much more highly mechanized Forces, appears likely here. While no doubt some of these anticipations will be falsified by events, taken overall they appear to justify the assumption that home demand will reach a level requiring an ingot production of 13 million tons.

In projecting forward trends regard must be had to the fact that in the decade 1950 to 1960 population is expected to reach its peak and commence to decline. The impact of this stability and subsequent decline on the capital goods industries is an important factor, likely to moderate the extent of increases in steel demand. For a number of years, however, the effect of this factor may be largely offset by the maintenance of employment at a higher level than before the war.

Direct Exports

Future direct exports of steel have been estimated at an average of 3 million ingot tons a year. They fluctuated widely in the inter-war period, the average over the 10 years prior to the war being 2½ million ingot tons. Considerable expansion in recent years has taken place in the local production in many of our largest export markets. In Australia, Canada and India expansions of capacity have taken place which exceed their pre-war imports. A doubling of the South African steel industry is planned, as well as important extensions in India and the Scandinavian countries. Production has been started in Turkey, and South American countries are also developing their steel production.

The following table compares production in 1937, which was generally the year of greatest pre-war production, with the highest level of production since reached in a number of countries which were important markets for British steel pre-war.

TABLE 5

Production of Steel Ingots and Castings (in Thousands of Tons)

	1937.	Peak production.
Canada	1,403	2,777 (1942)
Australia	1,169*	1,700 (1942)†
India	895	1,402 (1943)
South Africa	332	525 (1945)
Brazil	72	420 (1946)‡

* Year ended June 30th, 1938.
† Year ended June 30th, 1942.
‡ Annual rate based on production August–October, 1946.

In addition, America built new capacity of about 15 million ingot tons during the war period. In the 5 pre-war years annual steel production in America averaged only 37 million tons, whereas present capacity is some 85 million tons. Against the increases in available capacity in relation to pre-war consumption must be set the further prospective growth in world consumption of steel and the probable limitation of exports from Germany.

On balance it appears unwise to budget on a very substantial expansion of direct steel exports, particularly under conditions in which British coal prices, now the major single cost factor in steel production, have increased relatively out of line with American coal. The estimate of 3 million ingot tons represents an increase of 51 per cent. on the 1938 exports of 1,985,000 ingot tons. In addition it may be possible to increase further the proportion of higher valued products in steel exports. For example, in the Steel Development Plan special attention is being given to expansion of tube production in order to meet heavy export demands and to developments in other steel-finishing trades, for example, in tinplates and tyres, wheels and axles, where the product is of high value and the proportion of exports substantial.

The general trend towards the export of a higher proportion of the more highly valued products was an important feature before the war. The export of products valued at £24 per ton and over

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in 1938, namely tubes, tinplate, wire, castings, forgings, tyres, wheels and axles and alloy steel, rose from 23·8 per cent. of the total tonnage of steel exported in 1920 to 31·8 per cent. in 1930 and 43 per cent. in 1939. Further continuation of this trend may well mean that steel exports will reach the target of a 75 per cent. increase in value over 1938, measured in terms of 1938 prices, with a smaller proportionate rise in the crude tonnage figure.

Steel Imports

In the inter-war period steel imports fluctuated widely, reaching a high peak level of over 4 million ingot tons in 1927, immediately following the general strike, but in many other years amounting to almost 3 million tons. The importation assumed in making the post-war plans is 500,000 tons. The tendency is for steel to be readily available in periods of less active trade when there is a surplus of world steel capacity. Imports in these years can be obtained in very large quantities, but in times when demand for steel is heavy, imports are difficult to secure, as at present, and the prices at which they are available tend to rise above the British home trade price. In formulating a long term plan, particularly for an industry in which fixed capital in relation to turnover is so high, it is important that imports should be planned on a basis that avoids temporary inflows of large surpluses from other countries just at the time when home demand is contracting and reliance being placed on a tonnage which cannot be secured in periods of peak demand.

II. Raw Materials

In planning the future development of the industry, the total demand for steel has been estimated at 13 million tons home consumption and 3 million tons export, as indicated above. It is proposed that the capacity of the industry after rebuilding should be 16 million tons. Allowing, however, for some importation, and also for the probability that demand on the average will fall slightly below the full figure estimated, calculations of normal home output, and therefore, normal raw material requirements, have been based on an average home production of 15 million ingot tons. This would represent a rate of operation averaging 94 per cent. of capacity.

It is not proposed to elaborate within the compass of this Paper all the various considerations set out in the Development Plan regarding supplies of each of the raw materials, but rather to concentrate on examining more fully the future supply of scrap. Depending on the availability of steelmaking scrap will be the pig iron production required and the ore and coke requirements. In this connection it should be noted that while the bulk of the scrap arising is suitable for steelmaking, cast iron scrap is used in foundries and the inferior grades are suitable only for use in blast furnaces. It is particularly important that the maximum use should be made of all the steelmaking scrap available in this country. Not only does this save overall in the fuel required for the production of finished steel, it also saves both home and imported ore, and considerably reduces the total capital equipment required per ton of steel produced.

Sources of Scrap

The sources of scrap supply may be divided under the following four headings:

(*a*) Own circulating scrap—that is, scrap arising in the course of the steelmaking and rolling at the steelmakers' works and returning to the steel furnaces for re-melting.

(*b*) Bought process scrap—that is, scrap arising from engineering and other industries in the course of the fabrication of steel into finished products, including purchases of scrap from steel rolling firms not associated with the steelmaker.

(*c*) Bought capital scrap—that is, scrap arising from the demolition of buildings, ships, etc.

(*d*) Imported scrap.

Circulating Scrap

Just prior to the war circulating scrap was running at about 25 per cent. of ingot production. During the war the figures increased substantially to a peak of 31 per cent. in 1944 and fell to 27 per cent. in 1946. This rise in the war period was primarily due to the much greater proportion

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of alloy and other high grade steels and of products requiring more working and processing than the commercial steels produced in peace-time. With the future development of continuous methods of rolling, the proportion of circulating scrap may tend to fall further. This factor is somewhat offset by the general trend towards a higher proportion of lighter and flat rolled products where the scrap yield is higher compared with heavier sectional material; also by the probability that alloy steel production will, on balance, increase somewhat from the relatively low proportion to which it fell in the transition period of 1946. On balance it would appear reasonable to estimate that the circulating scrap on a 15-million ton basis will not fall below 25 per cent. This may be regarded as a fairly conservative estimate and may possibly be slightly exceeded.

Process Scrap

Figures regarding the supply of process scrap became available for the first time in the final Report of the Census of Production for 1935, which also published figures, in a slightly less comprehensive form, for 1934. Table 6 summarizes the results revealed by the Census.

TABLE 6

Sales of Iron and Steel Scrap by Certain Industries in 1934 *and* 1935 (*in Thousands of Tons*)

	1934.	1935.
Smelting works and rolling mills	543·0	587·8
Tinplate trade	185·0	179·2
Foundries	46·9	35·2
Wrought iron and steel tube trade	111·0	131·0
Wire trade	19·0	21·7
Chain, nail, screw and miscellaneous forgings trade	117·7	134·3
Railway carriage and wagon trade	32·6	67·9
Hardware, hollow-ware, metallic furniture and sheet metal trade	83·5	90·8
Mechanical engineering	158·3	201·6
Electrical engineering	34·4	33·0
Tool and implement trade	11·7	14·8
Cutlery trade and needle, pin and metal smallware trade	*3·0*	*3·3*
Shipbuilding trade	*15·0*	*18·3*
Motor and cycle trade and aircraft trade	*48·6*	*56·5*
	1,409·7	1,575·4

In a number of cases scrap sales recorded in the Census are in value terms, and it has been necessary to convert these figures into estimated tonnages. The Census returns so far as scrap is concerned are not altogether comprehensive, and for several important steel-using industries, notably the motor industry and shipbuilding, no figures are available. In the case of these industries, however, an estimate of scrap sales has been made from a knowledge of the steel they consumed. Where an estimate has been made in this way, the results are shown in italics in the table.

In addition to the new scrap returned from the industries listed above, there must be in the aggregate substantial tonnages arising from the engineering workshops attached to industries which were not asked to record scrap sales in the Census. There will also be tonnages from small firms having not more than 10 employees, which are excluded from the Census. These omissions make the figures an under-statement of the total process scrap returned from industry; on the other hand, part of the scrap will be diverted to iron foundries and to a much smaller extent to blast furnaces. In the absence of precise information on these points, it will be assumed that the scrap recorded in Table 6, excluding scrap from foundries, was returned to the steel melter as process scrap.

The most important factor affecting the future volume of process scrap is the total quantity of steel consumed in manufacturing industry in this country. In the five years prior to the war—1934 to 1938—total home consumption of steel averaged 9·65 million ingot tons. On the completion of the plan, home consumption of steel is estimated to average 13 million ingot tons over

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a five-year period. This represents an increase in home steel consumption of 36 per cent. over the pre-war average.

The question arises whether there are any factors which make it likely that the process scrap recovered from manufacturing industry will differ in relation to the steel used in future from that before the war. An important factor which might reduce the proportion of scrap returned is greater efficiency in the use of steel. This tendency is evident in the greater use of built-up and welded articles and of drop forgings in place of heavy machining of castings or forgings. On the other side, account has to be taken of the much higher proportion of lighter and more intricate products which will be produced in the future, where the final steel content may be smaller and scrap recovery greater than in the manufacture of heavier and less complex articles. If the proportion of flat products generally rises towards the higher American figure this again is likely to increase the supply of scrap compared with the pre-war period, when the proportion of heavy constructional work was higher.

On balance it does not appear likely that there will be any significant fall in the percentage of process scrap arising, and the increase in supply should follow fairly closely the increase in steel consumption.

Capital Scrap

By making use of estimates based on Table 6 for years other than 1934 and 1935, it is possible to separate three of the main sources of scrap supply—circulating, process and imported scrap—and from these figures and the known total availability of scrap to calculate broadly the capital scrap available each year. This analysis of the sources of scrap supplies is shown in Table 7.

TABLE 7

Sources of Steel Making Scrap (Thousand Tons)

Year.	Circulating scrap. (*a*)	Process scrap. (*b*)	Capital scrap. (*c*)	Imports. (*d*)
1920	2,128	1,163	298	436
1921	1,048	509	372	187
1922	1,669	816	1,112	105
1923	2,345	1,118	1,112	212
1924	2,093	1,288	450	459
1925	1,955	1,251	606	90
1926*	..	..	..	..
1927	2,421	1,515	1,140	71
1928	2,041	1,376	1,579	55
1929	2,369	1,497	1,459	68
1930	1,959	1,335	740	215
1931	1,178	1,095	925	98
1932	1,128	985	1,262	115
1933	1,467	1,153	1,895	104
1934	1,982	1,363	1,846	348
1935	2,245	1,540	1,800	438
1936	2,696	1,834	1,586	1,088
1937	3,076	2,053	1,345	955
1938	2,661	1,579	1,264	794
1939	3,570	2,222	902	624
1940	3,503	2,238	741	758
1941	3,324	2,268	984	512
1942	3,883	2,341	1,616	11
1943	3,904	2,354	1,467	..
1944	3,764	2,074	1,533	27
1945	3,405	1,705	1,895	137
1946	3,442	1,688	2,241	426

* Figures omitted—abnormal owing to General Strike.

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Circulating scrap shown in the first column in the table is taken from figures already published.* Column (*b*), showing process scrap, is based on the Census figures for 1934 and 1935. For these years the scrap sales of the re-rollers and tinplate makers have been calculated as a percentage of the semi-finished steel available; this percentage has then been applied to the semi-finished steel available in each year since 1920. Similarly the scrap accruing from the engineering and other industries has been expressed as a percentage of the finished steel available in 1934 and 1935, and this percentage has been applied to the finished steel available for consumption in this country in each of the years examined. Imports—column (*d*)—are taken from the Trade Returns, and the figures for capital scrap—column (*c*)—are obtained by subtracting the sum of columns (*a*), (*b*) and (*d*) from the total consumption of scrap in the steel furnaces each year plus exports. The resulting estimates of capital scrap consumption have been adjusted to allow for changes in scrap stocks since 1932. The figures since that date therefore show the annual deliveries coming forward to steelworks rather than the tonnage consumed.

(i) *Cyclical Fluctuations*

Two points regarding the supply of capital scrap emerge at once from an examination of the figures tabulated. The first is that supplies coming forward tend to increase when trade is declining and to fall away in periods of increasing trade activity. The relation of the capital scrap and steel ingot cycles is not uniform, and the figures suggest that the capital scrap cycle tends to lag fully a year behind the steel output cycle. Thus, one year after the 1921 low point in steel output, capital scrap supplies had risen to a peak level. On the other hand, following the 1929 peak of steel output, capital scrap by 1930 had fallen to the low point in its cycle. As steel output declined rapidly after 1929, so capital scrap supplies increased equally rapidly after 1930. The bottom of the decline in steel output was reached in 1931 and 1932 and the peak of capital scrap supplies in 1933. The rise in steel output after 1932 was associated with a marked decline in capital scrap supplies after 1933. The figures for 1937 indicate that in spite of the efforts made in that year to augment scrap supplies, it was not possible to overcome the strong tendency for capital scrap supplies to decline in a period of active trade.

These comparative movements of capital scrap and steel production are shown in Chart C, which shows steel production with the capital scrap figures brought forward one year.

It will be seen that the decline in capital scrap continued until 1940, a year after the highest level of steel production yet reached, *i.e.* in 1939. During the war period capital scrap supplies tended to rise, partly of course owing to the special efforts made to secure additional supplies from abnormal sources, such as railings, blitzed buildings, etc., and in 1945 and 1946 through the scrapping of war surpluses of various types.

The behaviour of the scrap cycle suggests that in periods of improving trade the new plant and equipment required by industry is used primarily not to replace, but to augment, existing equipment. The tendency to make additions rather than replacements, whether it be to the capacity of a factory or to the tonnage of a fleet of ships, becomes more marked as the peak of trade activity is approached. At the peak of trade activity the ear-marking of plant for scrapping reaches a minimum, and, since there must be some lag between the decision to scrap, or in this case not to scrap, and the accruing of scrap to the steel industry, it is approximately a year later before the capital scrap supplies to steelmakers reach a minimum. During a period of declining trade, much of the old plant which was retained during the preceding expansion will be progressively withdrawn from production and scrapped.

The question of scrap supplies has so far been discussed without any reference to the price of scrap. Since circulating and process scrap are mainly governed by the level of steel production and consumption respectively, the main item which should respond to changes in the price of scrap would be the supplies of capital scrap. Chart D shows the movements in prices of heavy steel scrap and the estimated arisings of capital scrap.

It will be seen that there is no apparent tendency for increased prices to be associated with increased supplies of capital scrap. The fluctuations tend to support the view that the supply is mainly governed by the considerations referred to previously, rather than by changes in price. Indeed, there is a good deal to be said for the view that the main factor on the price side

* British Iron and Steel Federation, *Statistics of the Iron and Steel Industry*, annually.

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CHART C

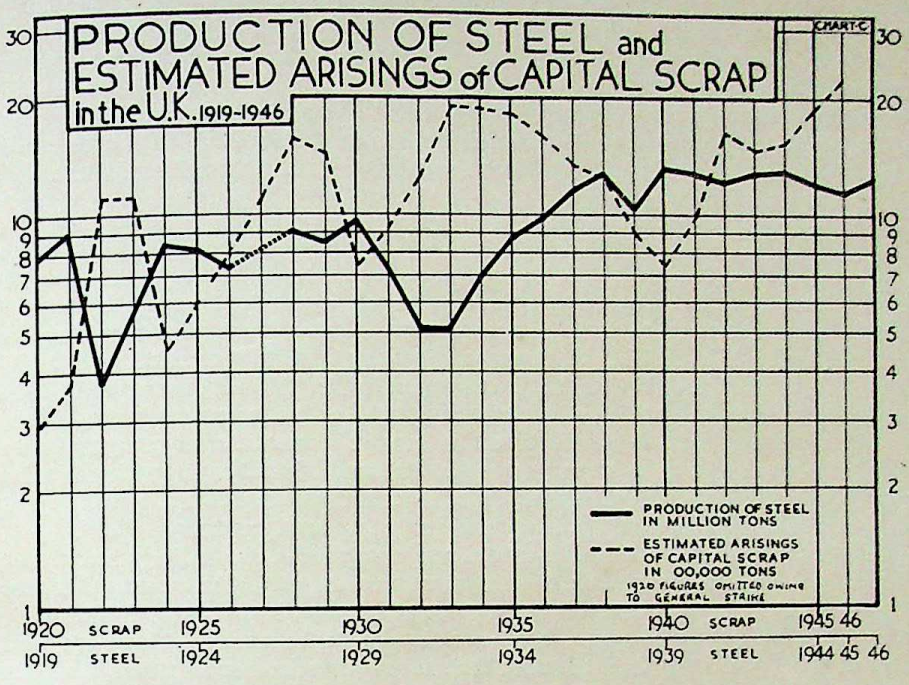
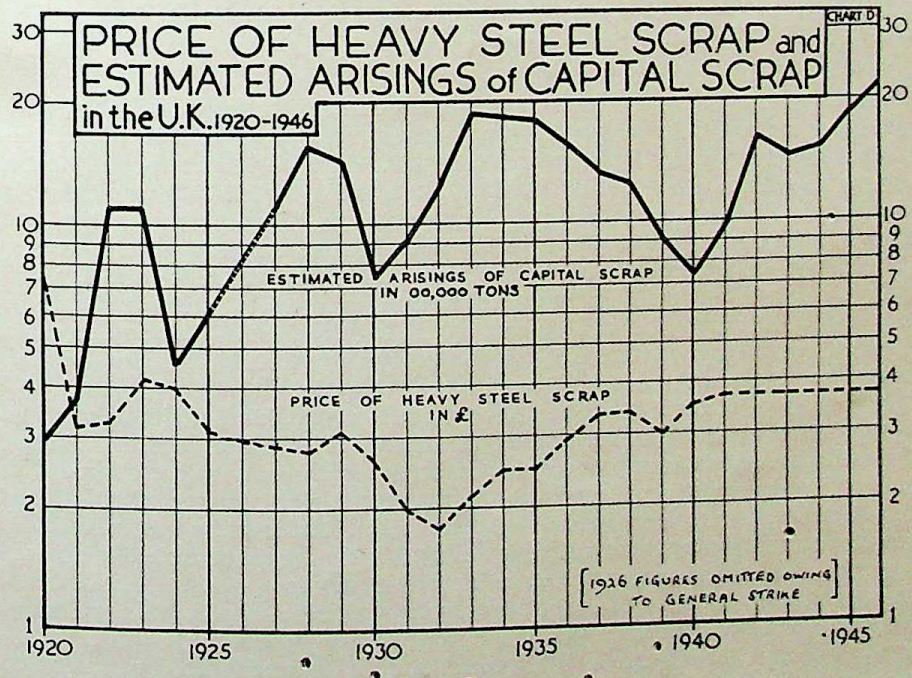


CHART D



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in promoting the flow of scrap is price stability, and that a fluctuating price at least tends on the whole to lead to the withholding of scrap in conditions under which it appears likely to move upwards. The policy in recent years has been to keep the price steady and to rely in the main on the natural factors promoting the growth of supply to operate, supplemented by exceptional measures which have contributed substantially during the war period to augment supply by recovery from marginal sources.

The cycle in the supply of capital scrap is of particular importance in causing the demand for steelmaking pig iron to fluctuate even more widely than the output of steel. Thus the consumption of pig iron by the steel industry fell from over 5 million tons in 1929 to 2·2 million tons in 1932, then rose to over 6 million tons in 1937.

(ii) *Trend in Supplies*

The second major point brought out by the figures relating to capital scrap is that underlying the cyclical fluctuations there has been a marked upward trend in supplies over the period as a whole. In the years 1920 to 1925 the average supplies available amounted to 660,000 tons a year, from 1927 to 1931 to 1,170,000 tons, and from 1932 to 1937 they averaged 1,620,000 tons. While the year-to-year fluctuations in capital scrap supplies are governed by changes in trade activity, the underlying trend is related to the volume of domestic steel consumption at some earlier period. As, in spite of temporary setbacks, the trend of steel consumption in this country over a long period has been decidedly upward, we may confidently expect that capital scrap supplies for many years to come will show, on balance, a marked upward tendency.

On the whole, the rate of increase in capital scrap supplies is decidedly greater than the rate of increase in steel consumption in this country over any equal period in the past fifty years. One possible explanation of this differential in the rates of increase is that there has been a gradual shortening in the life of machinery and other products made from steel. There are grounds for supposing that improvements in production technique and scientific advances have tended to accelerate the obsolescence of structures, plant, machinery, etc., while the proportion of finished steel output which passes direct into consumer goods, such as motor cars, hollow-ware, cans for food, etc., has tended to increase. Developments of this kind have a marked effect in shortening the average life of steel, and so augmenting the effect of increased quantities in use by its more rapid turnover.

Future Scrap Supplies

In estimating the probable forward supply of capital scrap it appears likely that an increase of about 35 per cent. over the pre-war supply, or an increase very similar to that estimated for process scrap, might be reached by the years 1950–1960. This would mean about 2,130,000 tons a year compared with an average of 1,570,000 in the period 1934–1938. This estimate is rather below the figure indicated by a projection of the pre-war trend of capital scrap arising, but makes some allowance for the fact that the average life of steel in use may not continue to decrease at the same rate, and for the probable increase in the proportion of steel being used by industry in this country which will eventually find its way into export markets and not be available for scrap. The effect of the latter factor on capital scrap supply, however, is likely to be delayed, and the strong upward trend in steel consumption in this country must inevitably have its effect in increasing the supply of capital scrap in the future.

As the analysis of the figures indicates, however, if the next few years are a period of high industrial activity and heavy demand for steel, the tonnage of capital scrap arising will for a time remain at a low level, apart from such tonnages as are secured from war demolitions. It is clear, for example, that the scrapping of cars and of plant generally cannot proceed quickly until new products are available to replace them. In the case of the steel industry itself, the development programme must largely precede the scrapping which will ultimately be possible. While, therefore, for a period of years capital scrap supplies are likely to be very low, making it necessary to secure the maximum possible quantity of imports to supplement home supplies, taking a longer view the overall position is likely to improve.

It looks as though the increase in both process and capital scrap would approximate 35 per cent., raising supplies, which averaged 3·24 million tons in the five pre-war years 1934 to 1938, to

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about 4·47 million tons. On the assumption that exports are negligible or very minor, the figure taken for the future available home scrap, other than circulating, is 4¼ million tons. It is on this figure that the estimate was made in the White Paper that there would be a total supply of scrap of about 8 million tons. This includes 3¾ million tons of circulating scrap estimated at 25 per cent. of ingot production. It leaves an import requirement of 250,000 tons to provide a 55 per cent. scrap ratio. This compares with a scrap usage in 1937 of 57½ per cent., or a total consumption of 7½ million tons used in the making of 12,980,000 tons of steel. The supply in 1937 was made up of 6½ million tons from home sources and 1 million tons from imports.

Scrap Imports

The foregoing figures are, of course, very speculative, and they may conceivably represent an over-optimistic assessment of future supplies. The increase estimated is so large that it may well be that a more cautious approach to the question is desirable. On the other hand, a conservative estimate has been made of available imports, and it is possible that additional supplies could be secured from abroad. Such additional imports may be particularly desirable to enable the upper limit of production visualized in the Plan to be exceeded if demand conditions make this desirable.

Of the imports, which averaged ¾ million tons a year in the four years prior to the war, about two-thirds came from the U.S.A. The supply of scrap from America in periods when the steel industry there is operating well below full capacity is substantial, and considerable tonnages might again be secured in such circumstances. Under present conditions, however, when capacity is fully employed, the whole of the American scrap is absorbed in domestic production. On the whole, it appears probable that a higher level of activity will be maintained in the United States, and it is very doubtful whether anything approaching the supplies secured in the years shortly before the war can be relied on again. The development of electric furnace production and the increased attention paid to the use of domestic scrap supplies reduce the possibility of securing considerable supplies from other countries. It would probably be over-optimistic to rely on securing imported scrap at an average rate of more than ½ million tons per annum in the future, apart from special possibilities in the next few years.

Pig Iron Supplies

On the basis of the foregoing estimate of scrap supplies, it is calculated that blast furnace capacity for the production of basic and hematite pig iron of approximately 9,100,000 tons per annum will be required to balance steel furnace capacity of 16 million tons and provide 500,000 tons of hematite iron for iron castings. This is an increase in pig iron capacity of 1,780,000 tons associated with an increase in steel capacity of 1,850,000 tons. Particulars of the proposed developments in blast furnace capacity are given in Section III of this Paper.

Location

It would at this stage be appropriate to consider in detail the question of location of plants in the industry, as this is related both to the distribution of the demand for steel and the sources of supply of scrap and of the coke and ore required for pig iron making. The question, however, involves such great detail that it is not practical to go into the issues in a single paper. There is one important point, however, that might usefully be made. It is that in the U.K. there are strong factors making for a greater degree of de-centralization of the industry than in a number of other steel-producing countries. This arises from two main factors.

On the one hand, there is the wide distribution of the markets for steel. This, of course, is partly due to the relatively high proportion of steel exported from the U.K. and thus passing through the ports, a percentage which before the war ran at well over 20 per cent. compared with just over 5 per cent. in the case of the United States. The existence also of important industrial markets in this country close to the ports means that home demand is widely dispersed throughout the country.

The second point is a parallel one, relating to raw material supplies. Two of the principal raw materials—coal and scrap—are again widely dispersed. In particular the coal supplies in South Wales, the North-East Coast and Scotland, reinforced by local arisings of scrap, are an important factor in making these areas attractive centres of production. The value of coastal

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sites is, of course, increased by the use of a proportion of fuel oil in the place of coal for the steel furnaces. The other principal raw material—iron ore—is in the main obtainable either in the form of high grade imported ore from Sweden, North Africa, Sierra Leone and other countries, or in bulk quantities, but of considerably lower iron content, from Northamptonshire and Lincolnshire.

The cost factors as between a steel plant based on home ore or imported ore are exceedingly difficult to balance precisely in a period of readjustment, such as the present, since all the elements may undergo substantial changes in the future. In particular, of course, coal prices, foreign ore prices due to high freight rates, and capital costs are all considerably above the general level of price increase in this country, and to get a fair assessment of the long term position involves careful consideration of the probable future trend of each of these items. On balance an appraisal of the situation, even within a fairly wide range of alternative assumptions, shows that it would not be economic to attempt to concentrate the whole production in one centre or even to approach such a situation. The sacrifice of low transport costs to the market and in the assembly of coal, scrap and other raw materials, would much more than offset any balance of operating cost there might be in favour of any one district. The Development Plan, in fact, provides a greater proportionate increase in steelmaking capacity in the areas with the low home ore cost but higher coal consumption and higher capital cost than in those based on imported ores.

Not only do cost factors limit any large scale change as between the main centres of the industry, but the increase in the proportion of flat products rolled by continuous methods, and the exacting demands placed on this material, gives a strong technical reason for basing much of the new capacity on sites well adapted for using the richer imported ores.

It is not intended to analyse the advantages of each location, but merely to draw attention to the foregoing points as a general background to Section III, which surveys the progress made in bringing into operation the Steel Development Plan.

III. Progress of the Development Plan

The plan for the future development of the steel industry was asked for by the Coalition Government on May 31, 1945. The industry was requested to submit its plans within six months, and in December, 1945, the Development Plan was submitted. In May, 1946, the present Government announced its general approval in principle of the more urgent parts of the Plan. In October, 1946, the Iron and Steel Board, whose establishment had been announced in the previous April, came into operation, and among its functions was the supervision of the development of the industry. Since that date specific schemes have been submitted by the industry to the Board, who have examined them and whose approval is required before the necessary licences or other authorisations are issued.

The Plan requires considerable care in timing owing to the limited heavy engineering resources for major constructional work in this country, and an important feature was the concentration on the more urgent parts of the Plan in the early years. Concrete schemes have, therefore, been submitted to the Board, after review by the Development Committee of the British Iron and Steel Federation, broadly in order of their urgency.

The original Plan envisaged a total expenditure of £168 million at 1945 prices. The schemes involved were to be started over a 5-year period and completed in 7½ years. So far schemes totalling £140 million have been worked out in detail by the industry and have been submitted to the Board for final approval. Approval in detail has been given to schemes totalling approximately £90 million, and on these it has been possible to make a start and they are in varying stages of progress at the present time. Certain further schemes have been generally approved by the Board, but there are still problems connected, for example, with housing, etc., which are preventing a definite start being made. With these the total passed by the Board amounts to approximately £125 million. The balance of the schemes submitted are still under consideration by the Board.

In setting out in Tables 8–10 the position regarding the Development Plan, the figures both for the schemes approved and for those at present under consideration by the Board have been grouped together to show the progress made in translating the general Plan into detailed and concrete schemes. Further, the schemes still under examination by the Board are in the main schemes which were approved in principle by the Government in May last year, before the establishment

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of the Board; so that while the examination may result in some changes, it would seem probable that in their general lines, which is the only aspect of concern here, they are likely to be approved and to fit at an early date into the original construction schedule. In this connection the Chairman of the Iron and Steel Board announced on April 28, 1947, that the Board accepted the aim of the Plan in relation to overall capacity, considered that it represented the practicable maximum over the next few years, and also accepted the broad distribution of capacity set out in the Plan.

Since most of the major schemes will take approximately three years to complete, the amount of new construction already completed is necessarily small. Later in the Paper an indication will be given of the extent to which the building at present going on will result in new capacity coming into use at an early date.

In estimating the extent to which the Plan has been submitted in detailed form for execution, the figure of the total expenditure on the schemes submitted of £140,000,000 in relation to the original estimated cost of the Plan as a whole of £168,000,000 tends rather to over-state the position. This would indicate that about 80 per cent. of the Plan has been put forward. Tables 8, 9 and 10, however, which relate to the progress in physical terms, show that about 58 per cent. of the blast furnace building, 80 per cent. of the steel furnaces and 66 per cent. of the rolling mill developments taken as a whole have been submitted to the Board. Thus, about two-thirds of the capacity to be built under the Plan has been put forward in definite schemes. The difference between the percentage in value terms and in physical terms may, of course, be due either to variations in the schemes as they have been worked out in detail, or to a rise in prices. Though certain of the schemes have been somewhat extended in scope they have followed closely the original intentions, and the main explanation of the change is an increase in cost in relation to the estimates made in 1945. Two-thirds of the total original cost of £168,000,000 is £112,000,000. The fact that two-thirds of the Plan is now costing about £140,000,000 would be consistent with an increase in costs of about 20 per cent., after allowing for certain developments of the original schemes. This in fact is reasonably in line with an estimate of the increase in costs since 1945 arrived at by an examination of the changes which have taken place in separate tenders and contracts. On the basis of a 20 per cent. increase in cost, the total cost of the schemes would amount to about £200,000,000.

The fact that approximately one-third of the total Plan has not yet been put forward in a detailed form to the Iron and Steel Board does not indicate any change in the general conception. The need to spread the building over a period of years gives an opportunity of reviewing carefully the later schemes, and as there must be envisaged a further stage of development, of considering them in relation to even longer term factors than are covered by the present Plan.

While the total new building submitted represents about two-thirds of the total building under the Plan, the increase in capacity resulting from the plans already submitted amounts to 86 per cent. of the total increase envisaged in the case of steel furnaces and 87 per cent. in the case of blast furnaces, as will be seen from Tables 8 and 9. The increase in capacity more closely corresponds to the ultimate increase because the more urgent schemes are in general aimed at expansion as well as increasing efficiency. Also, since the schemes are associated with a large scrapping of existing plant, much of which has still a useful life of a number of years, it will be possible, given flexibility in raw material supplies, to retain for a period some of this plant to achieve a high level of production pending the full completion of the Plan. Even when it is complete, if a capacity of 16,000,000 tons is inadequate, there would be the possibility of retaining for a time some part of the capacity of 4 million tons which it is ultimately proposed to scrap, and so permit an element of elasticity—given a corresponding elasticity of raw material supplies—in meeting requirements if they diverge materially from estimated requirements.

Steel Furnaces

Turning now to the position in more detail, Table 8 shows that on the steel furnace side new building totalling 4,148,000 tons has been submitted for approval as against the total in the original Plan of 5,835,000 tons.

In addition, arrangements have been made to convert approximately one-third of the steel furnace capacity at present using producer coal to the use of liquid fuel. This will, in general, contribute to increased output from the plants, which may offset the increased cost of firing with

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TABLE 8

Steel Ingot Capacity: New Schemes Already Submitted. (*Tons*)

	Present capacity.	New building.	Future capacity.	Increase in capacity.
South Wales	3,000,000	850,000	3,250,000	250,000
N.E. Coast	3,050,000	612,500	3,250,000	200,000
Scotland	2,000,000	235,000	2,115,000	115,000
N.W. Coast	360,000	—	250,000	— 110,000
Sheffield	2,100,000	13,500	2,100,000	—
Lancs, Flint, etc.	1,000,000	700,000	1,175,000	175,000
Staffs.	700,000	250,000	650,000	— 50,000
Lincolnshire	1,350,000	745,000	1,620,000	270,000
Northants	540,000	742,000	1,282,000	742,000
Total schemes submitted by the Industry	14,100,000	4,148,000	15,692,000	1,592,000
Total—Original plan	14,100,000	5,835,000	15,950,000	1,850,000

fuel oil. The main use of coal in the steel industry is, of course, in the form of coke for the blast furnaces, but the changing over of this high proportion of steel furnace plant may save up to about 1,800,000 tons of coal a year, or approaching 10 per cent. of the overall coal required in pig iron, steel furnaces and the primary rolling processes.

Among the main schemes already approved is the new steelworks at Margam in South Wales, with steel furnaces designed to supply the new continuous strip mill, which will produce approximately 1,000,000 tons a year of wide coiled strip as a basis for further continuous cold rolling into tinplate and sheet. Site preparation work has already started here, and the first new blast furnace in connection with this plant came into operation at the end of 1946.

The scheme for a new steelworks at Dorman Long's on the North-East Coast has also been approved. This plant incorporates a universal beam mill to produce broad flange beams, which will effect important economies in the weight of steel involved in structural work.

In Lincolnshire, extensions to the steel melting shop at Lysaght's have been approved, together with the scheme for the laying down of a modern continuous billet mill producing 450,000 tons of billets a year. Considerable progress has already been made, both on the steel furnace and blast furnace side, in expanding production in preparation for the installation of the new mill. A new melting shop at the Appleby-Frodingham Works has been approved and construction is well advanced, so that it should come into operation by the end of 1947. The modernization of the heavy section mills at these same works is also proceeding.

The re-building and enlarging of the Round Oak Works, based essentially on the scrap arising in the Birmingham area, has already been started.

A scheme is under consideration by the Board for the re-building and enlarging of the steel works associated with the Summers continuous strip mill for sheet production at Shotton.

The proposed expansion of steel furnace capacity in Northamptonshire has been approved in its general lines. In the original Plan provision was made for an increase in steel production in the Northamptonshire area, the essential features of which were that it should be based on home ores and would provide approximately 500,000 tons of billets per year, of which two-thirds would initially be available for outside sale. A detailed examination of the possibilities showed that the most rapid progress in reaching the objective would be by an extension on the site of the Corby Works. A scheme has therefore been worked out by Stewarts and Lloyds involving the expansion of production at Corby by rather over 700,000 tons of steel, mainly basic Bessemer quality, which will give the additional billets required for sale, and also provide a basis for the expansion of tube production made particularly urgent by the growing export demands.

A problem still to be finally resolved in connection with this scheme is the provision of houses for the additional workpeople required.

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The areas in which major schemes have still to be submitted are for the further re-building of steel plant in the North-East Coast area as a basis for continuous billet production, and the extension of blast furnace and steel furnace capacity in Scotland. In both these cases schemes have not the same urgency as certain of the other districts. Production of billets on the North-East Coast is already carried out in specialized plant giving many of the benefits of large scale production. In Scotland the problem of replacement of a large proportion of obsolete plant does not arise, nor is it one of the areas, (mainly those based on home ore), in which the main expansion of production was designed to take place.

Blast Furnaces

Table 9 shows that in the case of blast furnaces the schemes submitted provide for 2,775,000 tons of new building compared with 4,750,000 tons in the original plan.

Schemes approved include the extensions in South Wales in connection with the new South Wales Steelworks, the building of enlarged new furnaces at Lysaght's in Lincolnshire, and the addition of two new large blast furnaces at the Appleby-Frodingham Works of the United Steel Companies to replace smaller units. These will be added to the two large modern furnaces completed at Appleby in 1939 and provide a 4-furnace unit. A third furnace has been approved at Consett on the North-East Coast, which will be additional to the first modern furnace completed in 1942 and the second furnace which is expected to come into operation during the course of 1947. A third furnace is also being built at the Clyde Ironworks in Scotland, which will enlarge the two-furnace plant completed at the beginning of the war. Blast furnace developments at Corby are associated with the new steelworks extensions.

TABLE 9

Blast Furnace Capacity, Basic and Hematite: New Schemes Already Submitted. (*Tons*)

	Present capacity.	New building.	Future capacity.	Increase in capacity
South Wales	1,200,000	600,000	1,600,000	400,000
N.E. Coast	2,200,000	400,000	2,332,000	132,000
Scotland	650,000	225,000	700,000	50,000
N.W. Coast	650,000	—	650,000	—
Sheffield	150,000	—	150,000	—
Lancs, Flint, etc.	250,000	100,000	350,000	100,000
Staffs., etc.	400,000	—	400,000	—
Lincolnshire	1,200,000	600,000	1,400,000	200,000
Northants	620,000	850,000	1,280,000	660,000
Total schemes submitted by the Industry	7,320,000	2,775,000	8,862,000	1,542,000
Total—original Plan	7,320,000	4,750,000	9,100,000	1,780,000

The main schemes still to be submitted are those for the expansion of pig iron production in Scotland, and for the building of blast furnaces at the Shotton Works to replace and increase the supplies at present drawn from the Midland area. A major modernization of the blast furnaces on the North-East Coast was also envisaged in the original Plan. Approval has already been given to the scheme for modernizing the ore unloading and handling facilities in this area. This is proceeding at the present time, and the further plans for the replacement and rebuilding of blast furnaces on the North-East Coast are expected to come forward shortly.

Rolling Mills

Table 10 shows the extent to which schemes have been put forward on the rolling mill side.

In the case of billet mills, two schemes for development on home ore fields, in Lincolnshire and Northamptonshire, have been approved. It was always envisaged that development of billet production should first take place on home ore sites.

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TABLE 10

Rolling Mill Capacity. (*Tons*)

	Present capacity.	New building. Original plan.	New building. Schemes already submitted.	Future capacity (on basis of schemes submitted).
Billet mills	3,700,000	2,200,000	1,000,000	4.400,000
Plate mills	1,750,000	500,000	350,000	1,750,000
Joists, rail and heavy section mills	2,500,000	650,000	600,000	2,500,000
Sheet and tinplate mills	2,400,000	1,100,000	1,100,000	2,700,000
Light section, bar, rod and strip mills	3,175,000	1,000,000	650,000	3,500,000

A scheme for the building of a new 4-high plate mill, together with the concentration of the production at the Consett Works on plates, has been submitted, but not yet approved for immediate construction.

Proposals covering the main developments in the heavier section mills are well advanced. Modernization at the Appleby-Frodingham Works in Lincolnshire is proceeding. Modernization of the mills at the Round Oak Company, Birmingham, on medium sections is already under way. The scheme for the broad flange beam mill on the North-East Coast, which is much the most important scheme in connection with the modernization of the production of heavy structural material, has also been approved.

In the case of sheet and tinplates, the developments already referred to both in South Wales and Shotton have been approved. In the lighter mills, schemes have been approved for a new bar and rod mill integrated with the continuous billet mill in Lincolnshire and for further strip production at Corby. A wire rod mill at the works of Richard Johnson and Nephew has been approved, and construction is already well advanced. The new window section mill at Darlington is coming into full operation. The plans for a new rod mill at the Lancashire Steel Corporation have been submitted. Schemes have also been approved for developments in other finishing sections of the industry, for example, in tubes, tyres and wheels, wire and stainless steel.

Taken overall, the rolling mill schemes already submitted would enable most of the production target figures to be reached, as in almost all cases the new building proposed is considerably greater than the net increase in production envisaged. There is in most instances a substantial reserve of existing capacity, some of which can be retained pending the completion of the balance of the Plan.

Timing of Construction

The timing of construction has generally followed the line of priorities suggested as desirable in the original Plan. Priority has been given to a number of urgent schemes for developing output at existing plants where quick benefits would result. Indeed, some of the early benefits from the Plan will be realized during this year from new blast furnace capacity in South Wales, on the North-East Coast, in Lincolnshire and Scotland, from the steel furnace oil conversion programme and from new steel furnaces, particularly at the melting shop at the Appleby Works in Lincolnshire.

Among the major schemes, first priority was indicated as desirable for the new South Wales steelworks and strip mill for the production of sheets and tinplate. The second major scheme which was indicated as particularly urgent was the new broad flange beam mill on the North-East Coast, designed not only to give a highly efficient production of heavy structural material, but also to provide an important new type of product for the export trade. Of the new continuous billet mills which it was considered should be proceeded with urgently, the first was that at the Lysaght plant, and this has already been approved and constructional work on the early stages of the scheme begun.

The phasing of the building plans has been worked out in detail, and proposals for dollar requirements have been submitted to the Treasury. These involve a total dollar expenditure of approximately £15,000,000. This total is higher than the original sum of £9,000,000 estimated in 1945, owing to the higher prices of plant in America, and to some readjustment made necessary by limitations of construction in this country. The total expenditure in dollars represents about

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7½ per cent. of the Plan. Many of the items would not be obtainable in this country, but in the main the expenditure is designed to accelerate the completion of the Plan. Broadly, the extra time required to complete the Plan if dollar imports were cut down to very minor proportions would be approximately 4 years. The loss of exports and the additional imports required if the construction period were lengthened in this way would far more than offset the dollar expenditure involved in avoiding this delay.

Conclusions

No attempt has been made in this Paper to set out the benefits that may be expected to arise from the carrying out of the Steel Plan. Estimates of the fuel economy resulting, of the degree to which the Plan will involve production in large scale units of optimum size, and similar matters, were dealt with in the original Plan, and actual results will show how these are progressively realized.

One important matter mentioned in the original Plan should, however, be referred to. This was the prospect of co-operation of the Trade Unions in enabling arrangements for a continuous plant week to be operated in steel melting shops. Agreement on this matter has now been concluded, and the new arrangements came into force on April 6. This will have important benefits in increasing output from the plants, and in enabling the overall efficiency of the industry to be increased.

In this Paper I have attempted to give a fuller statement of the statistical basis of certain important aspects of the Plan, and to give some account of the progress made in carrying the Plan into execution during the first year following its consideration by the Government.

Discussion on Mr. Shone's Paper

Mr. Vibart, in moving a vote of thanks: In the past we have had more highly mathematical papers, papers with complex statistics and intricate conclusions, papers on obscure subjects, but the present author has joined together the old and the new and has done so in a new way. He has taken the old meaning of statistics as being figures descriptive of the State or of a certain organic part of it, and has applied them not just to the past but to the future progress of the industry. In future the Society when hearing a paper on industry will think of Mr. Shone's paper as a standard by which the quality of other papers is to be tested.

At the beginning of his paper he said that he did not think it necessary to follow the lines taken by the late Mr. Birkett in his two papers a good many years ago. The reason why he does not need to do so is significant. There has been such an enormous increase in the volume of statistics provided for the iron and steel industry, making it perhaps the best documented industry in this country, that such a course is no longer necessary. The various reasons for this include the decisions of the heads of the industry, as well as the influence of Control, but, coming down to the statistician's level, it has been due first to the introduction by Mr. Birkett of the Civil Service tradition of statistical sincerity, and to the way in which Mr. Shone himself has developed that tradition and taken every advantage of improvement and development to make the statistics more intelligent. There have been others who have taken part in that development; I do not know the names of many of them, but I should like to recall the name of Mr. Tubman as one of Mr. Shone's predecessors, and to-day there is Mr. Whitehead, who assists Mr. Shone on what may well be called the "production" side of statistics. I feel very strongly that if one is to get good statistical material it is not enough to have good statistical principles at the top. There must be understanding on the part of the people who are going to collect the statistics of the difficulties of those supplying them, together with considerable firmness in dealing with backsliders.

I should like now to deal with individual tables. Table I suggests that for the first two war years the country put a considerable tonnage—two and a quarter or two and a half million tons—into stock, and has not taken it all out even yet; I may be wrong in that interpretation, but that would seem to be the conclusion to be drawn from the figures.

Then there is the question of the analysis and forecasting of steel demand. I was very glad to hear that Mr. Shone as good as told us that the present classification by Government department symbols is just useless, and that he held out a slight hope that we might turn over on to something more rational. It is relevant for me to say here that the Company which I serve have made a move in

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that direction, and that we are at the present time analysing all our deliveries of flat steel in accordance with the purpose for which, as far as we know, they are intended to serve. It is probable that our analysis is more detailed than would be required for a national classification. We have about 70 items. We see, for example, not only whether steel is going for canning, but also to what kind of canning—fish, flesh, fowl, or good red herring—which might have an importance in relation to harvest and other matters, and similarly with cars, bicycles, radio, etc. But I hope that, although our analysis may be too elaborate, it may be possible to summarize it on lines which will link up with the classification on which the Central Statistical Office is now engaged. Let us hope that will be the next region into which Mr. Shone and others will introduce statistical civilization!

Going on to raw materials, I was a little uncertain about this demarcation between process scrap and circulating scrap. I had thought at first that process scrap was the scrap arising in all the industries outside the artificial boundary of the steel industry; but looking at the table, I do not think that is so, and I am wondering whether the relationship suggested between the scrap arising and the output could be to some extent affected by amalgamations between companies.

I think that the information regarding scrap will also want enlarging. It is unfortunate, for example, to hear that there are no statistics for the motor industry. I should like also to hear more about the relationship between British ore and the quality of steel.

But I must close on a more general note. Listening to the description of the original planned schemes and the proportion of those dealt with, and the number still remaining to be dealt with, etc., of all of which a very clear summary was given, and thinking, too, of what happened a year ago, and what some people tell us may happen in the coming autumn in the industry, I wondered whether you would forgive me if I suggested that some lines written by "Evoe" in last week's *Punch*, with the alteration of some words had a certain applicability to the steel industry:

"We liked our first plan," said Wren,
"But the Steel debate came and did stop it;
We liked our second, but then
The Steel Board took a while to adopt it;
We did not care for our third,
But the Minister gave us permission
To change what we thought absurd,
So we have the present edition."

Mr. SARA, in seconding the vote of thanks: I think the Society is to be congratulated on having a paper of this kind. There are at present a large number of organizations which, if they do not essentially govern industries, do at least have a great influence over large sections of industry; and the various nationalization measures which are on the statute book, or in prospect, will create other institutions of the same kind. I think it is a very good example to set at this stage, that officers, statistical and economic, of organizations of that kind should come before this Society and explain, in rather greater detail than the public relations officer would be able to do through the newspapers, or than the "brass hats" of the industry could do, the kind of considerations which have gone to the making of decisions. This is the kind of audience which is capable of discussing them.

Secondly, I am grateful that Mr. Shone has given us an example of practical statistics. He mentioned at the beginning of the paper that some of the methods employed are not very elaborate, but that decisions had, for practical reasons, to be taken on what evidence there was. There was a saying among statisticians who were temporary civil servants during the war that the most complicated piece of statistical apparatus required was a knowledge of moving averages. It was said by way of a joke, but there is a lot of truth in it. This paper is very largely the result of that kind of practice. Much of the information available will not admit of more elaborate methods of analysis, but some analysis has to be made because some decision has to be reached.

We cannot, of course, be at all certain how the future balance of exports and imports will work out. Prophecy is dangerous, but I think myself, from a study of past trends and future prospects, given a measure of full employment in this country, that the estimate of home demand at 13 million ingot tons is too low.

The main evidence for suggesting that 13 million ingot tons is too low is to be found in the present level of demand for steel. It is commonly alleged that this is due to an unhealthy expansion in the metal and metal goods industries. If you look at the growth of manpower in these industries since, say, 1924, you find that almost all the individual industries comprising the group show a steady rise over the whole period, except for the slump in 1931/2. Despite the wartime expansion of these industries, the figure for 1946 is in many cases lower than would be expected by roughly

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projecting the rate at which they were increasing before the war up to 1939. About 80 per cent. of the home production of steel goes into the industries that are called by the Ministry of Labour the metal and metal goods group; those industries are at present making a very large demand, but not the full demand they may well make when their production is flowing properly.

The standard industrial classification sponsored by the Central Statistical Office is mentioned. I should like to make a plea that when it is settled, the list of firms, graded into industrial categories, should be made public. That is, of course, a matter for the Government, but it does seem to me that if firms knew into which category they were classified, and which other firms were grouped with them, they would be able to make reasonable suggestions about their removal from one category to another. The steel firms themselves could supply a great deal of valuable information on the consumption of steel, industry by industry, if there were a standard industrial classification, and if the names of the firms (or plants) included in each industry were known to them.

If the demand for steel in the home market has been under-estimated, we shall need more capacity. The author has shown, I think for the first time, to what extent we shall be able to meet that with our present plans. It is clear from the figures in the third section of the paper that we have already made considerable progress towards the total increases of capacity in the various sections of the industry. He has not gone so far as to estimate how much more we could get out of the industry at various dates in the future by leaving the maximum amount of old plant in operation. I do think that might be examined to see to what extent we could cope with the greater demands which, I think, are bound to arise.

The vote of thanks was put to the meeting and carried unanimously.

Mr. CAIRNCROSS said that this was a model of what a paper on industrial statistics should be. He was glad to see the Society continuing the tradition, which had a very long history, of using the mass of statistics of an industry in order to provide the non-expert with a broad survey of its trends and problems. There were so many novelties in the paper that it was possible only to comment on one or two—the analysis of the demand for steel, for instance, and the whole of the section on scrap. He rather suspected that the estimate of the future demand for steel might prove to be on the low side. Those who had been rash enough to make predictions in the past had nearly always been proved to have been a long way out. But if they took note of the increase that occurred between 1913 and 1927 and compared it with the increase assumed between 1939 and 1953, there were some grounds for supposing that an output of 15 million tons, while sufficient for some years, would not be sufficient for all years in the early nineteen-fifties.

One point that was rather obscure in the calculation was the treatment of "indirect" exports of steel. The figure for home demand did not represent the total requirement of steel for home market consumption; it represented the steel for that purpose and for exports of machinery, motor cars and other engineering products. These indirect exports were almost certain to expand greatly in relation to prewar figures. As to the other constituents of home demand, judging from what was happening in America, the large arrears of building and so on, there was at least a reasonable prospect of a further increase. As the last speaker had suggested, however, there was a loophole in the amount due for demolition under the plan if the demand proved to have been underestimated.

In steel furnace capacity the total amount of construction now planned was about 40 per cent. of existing capacity, and that construction would have to make up the arrears of the last ten years, and cover the requirements of the next five or more. Thus in fifteen years the average rate of building, both for replacement and extensions, would average only about 3 per cent. per annum of pre-war capacity; this did not seem particularly extravagant. If the price of capital was lower than it used to be, there was a good deal to be said for ensuring that they tried to rebuild the steel industry, not over 100 years or even 50 years, but more frequently. There should be no disposition to assume that, with the completion of the present plan, the scale of new construction would necessarily slump.

The other point he wished to touch upon concerned scrap. He was not quite clear from the paper whether an allowance had been made for scrap obtained from imported metal. He was interested also in the estimate given of capital scrap. People were puzzled to know what had happened to all the steel made in the last hundred years. How much rusted away and how much came back to the steel furnace? Was it possible to work out the proportion that was eventually re-melted? And what was the proportion of new metal to old in the current output of finished manufacture? Looking at the figures in the paper it would seem that the amount of capital scrap becoming available was probably about 50 per cent. of the amount of finished steel consumed in Britain, say, twenty or thirty years ago. That was a rough guess; probably Mr. Shone would be able to give something more reliable.

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One final point on scrap. Mr. Shone had made a reservation about the next few years. He would have thought that for quite a long time—certainly five years or so—the amount of scrap available would be inflated by supplies from Germany, where there was more than human eye had ever lighted on before, from American ships, some of which were laid up and must be scrapped, and from other sources of that kind.

Professor JONES, in congratulating Mr. Shone on his paper, said that the two previous speakers had referred to two points upon which he had intended to make some observations. The first was the probable demand for steel in the future, and therefore the adequacy of the present plan of reconstruction and development. When he first read the account of the plan he had felt that the estimate of future demand was too modest and, in reaching that conclusion, he had been influenced by what had happened after the first World War. The producing capacity of the industry in the United States had been enormously expanded during that war, and it was generally believed that the industry would need to be contracted, both there and elsewhere, to meet the normal requirements of peace. What actually happened, however, was a continuous increase in producing capacity. In the United States, as they all knew, there was a tremendous increase in the demand for steel for motor vehicle construction and for skyscrapers, and in a very short time it was necessary to increase the producing capacity of the industry by approximately one-half, even as compared with the capacity existing at the end of the war. An examination of long term trends showed that the consumption of steel per head of population steadily increased, allowing for cyclical fluctuations. Having regard to the fact that the Government hoped to develop backward countries and to raise the standard of living of the people of those countries, the prospect of the iron and steel industries, not only in this country, but in the world as a whole, was such as to suggest the need for further expansion on a large scale.

On second thoughts, however, he felt that the plan could be defended. It was not intended as a complete and final plan beyond which no further development was to be expected. It was simply a plan for to-day, and he assumed that before the plants included in the scheme of reconstruction and development had been completed plans for further development would be prepared. Having regard to the fact that we were almost within reach of the maximum working population, such further development could not be immediately undertaken. Thus, for present purposes, while the estimate appeared at first to err on the conservative side, it was probably sufficiently high, having regard to the enormous demands upon our manpower in the immediate future. But it was important to stress that it represented reconstruction and the first stage of development.

Like previous speakers, he was very much interested in that section of the paper which dealt with the problem of scrap. He was particularly interested in it as one who was born and had spent his early years in South Wales. The industry in that part of the country had been based very largely upon cold pig iron and scrap, and had therefore been unable to avail itself of those economies arising from the conservation of heat. In Lincolnshire, on the other hand, steel production was linked with the production of pig iron in the blast furnaces, using local ore; it used less scrap per ton of steel, and was able to enjoy the economies due to the conservation of heat in a continuous process. The relative efficiencies of the two types depended largely upon the availability and the relative price of scrap, which would thus have a very serious influence upon both the structure and the location of the iron and steel industries in the future. If, in future, scrap was likely to be scarce and its relative price high, the case for reconstructing the industry along the line of integrated plants and continuous operation from the blast furnaces was correspondingly strengthened. He believed that such a situation would arise, and was therefore forced to the conclusion that the present South Wales scheme was along the right lines, using the criterion of real costs, in spite of the fact that his own native town and area was likely to suffer. There would have been an argument for making greater use of the steel furnaces of West Wales, which, in the long run, would be injured by the plans for reconstruction and development farther east, if scrap was likely to be available in great quantity and at a relatively low price. But it was necessary to look beyond the next four or five years, when there might be a large supply of cheap scrap available in consequence of the war, and to consider the situation that would afterwards arise and be maintained. This had no doubt been in the minds of the people responsible for the South Wales plan. Similar considerations would also arise in other parts of the country. It would thus be seen that the second section of Mr. Shone's paper, which might appear at first sight to be concerned with a matter of comparative detail, was of the first importance. The three sections were inter-related and formed an integral whole. The estimate of future demand was bound to influence the scheme of reconstruction and development for the country as a whole, and the relative measures and rates of development in different parts of the country. It was an interim scheme conditioned by the availability of manpower within the next few years. Long before it had been completed further schemes might reasonably be expected based upon the ultimate growth dictated by future world conditions. The

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second section of the paper showed that the location factors in the industry and the desirable technique were seriously influenced by the availability of scrap and the relative prices at which scrap would be obtainable in the future.

Finally, the success of the plan itself would be determined by the extent to which the factors brought out in the first two sections were appreciated. He would therefore like to associate himself with the previous speakers in thanking Mr. Shone for a statistical paper which had an important and immediate bearing upon the policy of the industry.

Mr. E. D. McCALLUM said that few British industries could rival steel in the excellence and abundance of the statistical information which for many years it had made publicly available. The statistical publications of the British Iron and Steel Federation provided a model which could with advantage be followed by the central organizations of many other industries. To Mr. Shone and his predecessor Mr. Birkett much of the credit belonged. Only those who had had inside experience of the complex problems of collection, scrutiny and tabulation of mass industrial statistics could properly appreciate the great amount of difficult and painstaking work involved.

A special merit of the paper was that it broke new and difficult ground. It was not confined, as it might have been, to a commentary on the wartime achievements of the industry or, more accurately, to as much of them as was revealed in the statistical record. Mr. Shone had merely suggested the very considerable additions to British steel statistics which the wartime administration of the industry necessitated and made possible. Figures of the consumption of raw materials and of production of numerous classes of semi-finished and finished steel, particularly of alloy and special steel, had been extended and improved, and figures of stocks of steel had been made available for the first time. The tracing of deliveries of a wide variety of forms of finished steel to more than 20 different Government departments and amounting to some 10 million tons annually was in itself an achievement of which Mr. Shone might have made much. He had chosen instead the more difficult and perhaps more hazardous task of setting forth the statistical basis of the iron and steel development plan.

The plan envisaged an increase of 1·85 million tons in steel ingot capacity and 1·78 million tons in basic and hematite pig iron capacity, together with numerous additions and modifications at the semi-finished and finished steel stage. At current prices the execution of the plan was likely to cost £200 million spread over 7½ years. Clearly a scheme of this magnitude, involving an annual average capital outlay of about £27 millions for this industry alone and to be undertaken during a period of great scarcity of capital and labour resources, called for the most careful scrutiny. The approval of the bulk of the plan by the Iron and Steel Board and presumably also by the Cabinet implied that the case for it was convincing. Nevertheless, caution was essential. The crux of the matter was, of course, the accuracy of the forecast of a total demand of 16 million ingot tons a year in the years after 1950. In view of the great expansion in steel capacity in foreign and Commonwealth countries and the uncertainties in the international situation, the estimate of 3 million ingot tons for direct export was probably as good as any. But it seemed to him that the real difficulty lay in the estimate of 13 million ingot tons for home requirements. Mr. Shone's case, if he followed it correctly, was threefold. In the first place, it was the figure suggested by a consideration of the long-term trend of home consumption of steel. Forecasts of this kind were difficult to make with certainty. They depended upon latent assumptions, including the character and pattern of the future industrial development of the country. In the second place, the estimate appeared to be supported by a consideration of the trend of steel consumption in individual industrial groups. In this case the estimate was based on data which were themselves estimations. The author himself pointed out that it was difficult to obtain "reasonably accurate figures" of industrial consumption. In countries such as India where the number of producers and the tonnages involved were small and where the central controlling authority itself placed orders on producers, a double classification by authorizing department and industrial consumer would be comparatively simple, but in this country the position was altogether different. In view of the difficulties in using the data provided by the steel distribution scheme for this purpose and the impracticability of superimposing an analysis of deliveries by consuming industries on the departmental analysis, it was much to be hoped that a modification of the existing steel distribution scheme classification on the lines suggested by Mr. Shone might be found practicable.

In the third place Mr. Shone implied that the fact that consumption in the fourth quarter of 1946 was at the rate of 12¾ million ingot tons supported the reasonableness of a future requirement of 13 million ingot tons. But a specially favourable quarter in a post-war reconstruction boom might be quite exceptional. In short, therefore, there were some grounds for the view that a post-war aggregate requirement of 16 million ingot tons might be on the high side. In any case it seemed certain that shortages of fuel, labour, and scientific and managerial staff would for some considerable time impose severe limitations on the expansion of the steel-consuming industries

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and of the steel industry itself. On these and on some other aspects of the position the silences of Mr. Shone spoke louder than words.

On the details of the plan it was impossible to speak without inside knowledge. Problems of location and degree of integration of processes were highly technical and frequently controversial. They must, he thought, be left to the judgment of experts, subject always to the general approval of the Government. In conclusion he thanked Mr. Shone for the new figures relating to the supply of scrap, and in general for an interesting and valuable contribution to an important problem of economic statesmanship.

Mr. D. J. LISTON wished to raise two points of detail. First, he thought those engaged in collection of statistics for the iron and steel industry would do a very valuable service, once the new census schedules were published, in helping to compile some form of comparative statistics that would assist in remedying the defects of the past. In the one industry of which he had particular knowledge, hardware and hollow-ware, consumption of steel was stated to be 790,000 tons per annum—a very high figure, almost as high as in the ship-building industry. It was explained by the fact that for census purposes all the tinplate used by the canning industry and the tin box industry were classified as hardware, hollow-ware, etc.

Those responsible for the collection of statistics in the basic and consuming industries might well get together, and try to see whether from their special knowledge they could remedy some of these defects and so formulate a continuous series for statistics which had been inadequately gathered in the past. The industry with which he was connected—large consumers of tinplates—would be very glad to lend their assistance.

The second point he wanted to bring forward concerned estimates of future demands for steel. Had any attempt been made to plot the growth of the iron and steel industry side by side with the growth of competing industries? He had in mind development trends in the aluminium industry. Obviously the demand for one metal was to some extent related to the demand for others. If the developments of respective industries were seen side by side, it would help in the appreciation of the development of the iron and steel industry in relation to the general trend in the metal group of industries.

Mr. SHONE said that he would reply only briefly to some of the points raised. He much appreciated the remarks which had been made, the usefulness of the comments and the interest shown in the paper.

It had been pointed out that a great deal of steel appeared to have gone into stock in the early years of the war. There were very big imports from America in 1940–41, and a good deal was tucked away into stock and came out in 1942–44. He was afraid that it had not quite all come back, and the explanation might be that some had been accounted for as scrap.

Circulating scrap was affected somewhat by amalgamations, and it was certainly affected by the high proportion of alloy and special steels, all of which produced variation in the circulating scrap figure.

It had been asked whether the figure of 13 million tons for average home demand was low or not. More than one view of the answer had been given by several speakers in the discussion. There were a number of factors which would lead to a cautious view. For example, there were economies in the use of steel. The development of welding was saving steel, and there was also considerable development in the high tensile steels, greatly reducing the weight of steel in building. A proportion of the present demand arose from the substitution of steel for other materials and it was difficult to judge how long this would go on and whether the position might be reversed.

The position after the last war had been mentioned. There were very optimistic forecasts made by steelmakers then about the rosy future and the big capacity they were building. Some of the forecasts now looked ridiculous; in fact, in most years between the two wars steel capacity was very seriously under-employed.

Another factor bearing on future production was the raw material position. It was exceedingly doubtful if sufficient coal, in particular, would be available to support an extension much beyond about 16 million tons. There was a good deal of flexibility on the capacity side. The limitation was not likely to be on the capacity side, but on the possibility of making use of it.

The extent of new building had been referred to. He did not think the programme was unduly ambitious in view of the admitted need to overtake arrears, arising particularly from the war, when no major building could go forward, and the greater rate of progress towards general mechanisation after the war. The plans provided for about six million tons of new steel capacity being built, of which two million tons were for increases and four million tons for replacement. Four million tons on a capacity of about 14 million indicated a proportion of 25 or 30 per cent., and suggested a life of the steel plant of 20 to 25 years. That was quite a high rate of modernisation,

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even apart from expansion, though as Professor Jones had mentioned, this was only a stage in the Plan and the stage when schemes should be started and be got well under way. After the next five years it would be necessary to formulate plans for the ensuing five years. But in the meantime the present plan seemed to be about the maximum that could be obtained having regard to the great claims on the capital equipment and building industries of this country.

A further interesting point concerned scrap from imported steel and whether allowance had been made for it. This had been taken into account in the calculations. The average life of steel and the average amount returned to the furnaces were further interesting points. Apart from steel exports, some of the steel went out in articles from which it was not worth recovering the scrap. Reference had been made to the description of the next five years as a period in which there was rather an expectation that capital scrap supplies would be low notwithstanding the general long-term upward trend. The reference was, of course, to the possibility of other sources of supply, from Germany, laid up American ships, and so on. It was hoped that substantial tonnages could be got from such sources, especially from Germany, to help the raw material position in the next few years of abnormally high demand. It was particularly important to get scrap because it would save pig iron production, and therefore economise coal supplies.

He thanked all those who had spoken for their interesting points and the audience generally for the kindness with which the paper had been received.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:—

Ibrahim Al-Khedairy.
Bernard Norman Darbyshire, B.A.
Eric Dawson.
Laurence Walter Desbrow.
Stuart Dixon Dorizzi, B.Sc.
Thomas Edward Easterfield, M.Sc., Ph.D.
William Ernest Felthouse.
Norman Douglas Hill.
Sayyid Hamid Kadhim.
Tom Edward Mitchell, B.Com.
Donald Cyril Murphy, M.A.
John Richard Parkinson.
Maurice Charles Polman, F.I.A., A.A.S.
Rose Scheuer, B.Sc.(Econ.).
Arthur George Ernest Smith, B.Sc.
John Leonard Spencer Stoneman, M.A.
Heinrich Walter, Dr. jur.
Joan Mary Willson, M.A.

Corporate Representative

Reginald Edwin Beales, F.I.A., representing the Central Statistical Office.

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The Proposed Third Statistical Account of Scotland

By J. G. Kyd,
Registrar-General for Scotland

[Read before the Royal Statistical Society, June 26th, 1947,
Dr. David Heron in the Chair]

I deem it a high honour to have been asked to submit a paper to this Society on the Third Statistical Account of Scotland.

I think it well, at the outset, to mention that in addition to the two published Accounts there were earlier attempts to collect descriptions of the various parishes of Scotland on a national scale. The most important of these appears to have been that of Sir John Scot, a descendant of the House of Buccleuch. About the year 1650 he presented a "supplication" to the General Assembly of the Church of Scotland entreating that certain ministers in each province might be appointed to furnish descriptions of their several districts. This supplication was approved and the appointments made, but few of the clergy responded, and the material obtained from those who did was scanty. In applying to the parochial clergy for statistics Sir John Scot was a pioneer in the series of Statistical Accounts of Scotland, the first of which was completed a century and a half after his venture.

Before I attempt to describe what we hope to undertake in our enquiry, it is well, I think, to place on record some facts relating to the two previous Statistical Accounts.

The First Account was really the work of one man, Sir John Sinclair, Baronet, of Ulbster, Member of Parliament and first President of the Board of Agriculture of Great Britain. Sinclair was a man of great determination, and no one can look at Raeburn's wonderful portrait of him without realizing his force of character.

Sir Henry Craik in his "Century of Scottish History" is rather caustic in his observations on Sinclair, declaring among other things that "he pursued statistics with the ardour of an infatuated lover." Notwithstanding all Craik's rather flippant observations Sinclair was a great benefactor to Scotland, and the First Statistical Account will ever remain as a memorial to his energy.

Although Sinclair's Account contains a report on every parish written by the parish minister, his original idea was to draw up from the returns submitted by the individual clergy "a general statistical view of North Britain without any particular reference to parish districts." He goes on to indicate, however, in his introduction that for the reason that he found such merit and ability and so many useful facts and important observations in the answers which were sent to him, to use his own words: "I could not think of depriving the world of the credit the clergy were entitled to derive from such laborious exertions, and I was thence induced to give the work to be published in its present shape."

Sinclair sent out to all the ministers a list of 160 questions—40 dealing with the geography and natural history of the parish, 60 respecting population, 16 regarding production and 44 miscellaneous questions.

When the first volume was printed many of the clergy expressed a desire to have a particular form laid down for presenting the statistical account of their respective parishes, and Sir John included in his first volume a plan of some 70 headings for the guidance of the individual parish ministers.

An examination of the queries drawn up for the purpose of elucidating the state of Scotland reveals the very wide vision of the project.

Sinclair was of opinion that it would have been desirable to have published the Accounts of the different parishes arranged by presbyteries or counties, but as the individual clergy did not submit their Reports at the same time, it was thought advisable to throw as much variety as possible into the volumes, and the individual parish reports were bound into 21 volumes of approximately 500 pages each without any order or sequence—the date of their publication being determined by their submission to the compiler.

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In the 40 points dealing with *geography and natural history* of the individual parishes, questions were asked as to the ancient and modern name of the parish and the origin and etymology of such names. Sinclair desired to know not only the area, but sought information on the general appearance of the country, the nature of the soil and the atmosphere, the most prevalent distempers and their cause. He enquired as to the species of fish in the lochs and rivers, and as to whether such rivers are navigable. The nature of the seashore of any parish by the sea, the animal and plant life of the inland and seaward parts of the parishes, the course of the tides, and any special natural features of shore, mountain, loch or river were all subjects on which he sought information. Facts were required of any land battles or sea fights, any minerals—particularly coal-mines—and whether the parish was subject to inundations or land floods. Any remarkable mischief which had been done by thunder, lightning, water-spouts or whirlwinds had to be recorded, and whether there were any remarkable echoes. These 40 questions dealing with geography and natural history alone surely gave great scope to the local ministers in surveying their own parish.

The 60 questions regarding *population* deal not only with the trend of population in the past, but with its present distribution, the annual vital statistics in regard to births, marriages and deaths, and the number of centenarians, with the social classes of the people and their occupations, also with migration to and from the parish. Several of the clergy, from the data which they had gathered, constructed tables which I believe are the earliest attempts, in Scotland, to use scientific methods for measuring mortality and morbidity.

The 16 questions on the *production* of the parish deal mainly with agricultural pursuits, the type of farm, whether the parishes are self-supporting or whether food supplies are exported or imported. The acreage under various crops and the amount of live stock are all dealt with under this heading.

The remaining 44 miscellaneous questions are very wide in their concept, and deal with such matters as to whether the parish has any peculiar advantages or disadvantages, the derivation of the place-names, the rental of land and houses, the value of the minister's living, whether he is married or a widower or single, and what family he has of each sex.

Particulars as to the number of poor in the parish and the amount contributed for their maintenance, the price of provisions, past and present, the rate of wages, what fuel is consumed, the number of ancient monuments, and antiquarian objects which have been dug up in the parish and in whose custody they rest, are all brought within this survey.

Such quaint questions are asked, as whether there are any people in the country remarkable for strength, size, complexion or for rare physical or mental qualities; particulars as to average height, and the greatest height to which any man in the parish has grown. Enquiry is made as to the character of the people, whether they are economical or extravagant, disposed to humane and generous actions, and whether they enjoy to a reasonable degree the comforts and advantages of society and are they contented with their situation and circumstances; and further, whether there are any means by which their conditions could be ameliorated?

Sinclair in an addendum to these 160 questions asked six further questions dealing with the state of the roads, the rent of the best arable land, the size and the average rent of the farms, and he asked also whether there were any curious or important facts likely to have produced any great alteration in the manners, customs, dress or style of living of the inhabitants of the parish compared with 20 or 50 years earlier.

One can imagine the state of perplexity which must have been in the minds of the recipients of this formidable questionnaire, but judging by the type of report which was written by the individual clergy, Sinclair's directions were closely followed. Although naturally when dealing with more than 1,000 individuals there was great variety in the presentation of the details—some were terse, short and somewhat superficial, and others extended to many thousands of words and went into the minutest particulars with great detail.

The most interesting part of the individual accounts is naturally to be found in the general observations of the parish minister himself. It is impossible here to give more than one or two examples of the diverse type of information supplied, but I would instance the case where one parish minister describes the method used by one of his parishioners in dealing with the lover of an unfaithful wife! An interesting sidelight is thrown on the effect of quelling the Jacobite rising in the middle of the 18th century when one reads in the account by the minister of a highland parish that "Before the year 1745 this parish was constantly exposed to depredations from their neighbours

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in the West Highlands who came and took up their cattle and their property, without ceremony, for which they made no compensation. Now by the exercise of the laws and a well-governed police, property is as secure as in any part of the Island." There is contained within the volumes of the First Statistical Account a mass of information of great historical and local value, the study of which, not only shows the conditions of life in Scotland 150 years ago, but is of the greatest help in making comparisons with those of our own time. After Sinclair had completed the 21 volumes containing the Account he published two Appendix volumes which review in a masterly manner the various aspects of life and conditions in Scotland as revealed from an examination of the reports of the individual clergy.

The task of extracting reports from every parish in Scotland was not completed without considerable difficulty. The first printed circular to the clergy was dated May 25, 1790. Some of the clergy responded quickly, but before the final Report was completed, no less than 25 appeals had to be sent to the delaying clergy, and the last Report was not received until the latter part of 1797.

It is amusing to notice the increasing fervour shown by Sinclair as the number of his appeals increased. Various methods were used by him to induce the dallying clergy to come up to the mark. One letter dated November 1, 1794, has the following amusing postscript: "N.B.—Large parties of the Rothesay and Caithness fencibles are to be quartered upon all the clergy who have not sent their statistical account on or before the term of Martinmas next, so that the Ministers have it in their choice either to write to the Colonel (that is to Sir John Sinclair) or to treat his soldiers." The last heroic effort, which apparently proved successful, with the aid of certain "statistical missionaries" which the General Assembly of the Church of Scotland sent out, was actually written in red ink in Sinclair's own hand, and is in the following terms: "Sir John Sinclair presents his compliments to ——. He sets out for Scotland (from London) next week and will be much disappointed indeed if he has not the pleasure of finding the Statistical Account of your parish ready for him, as on his arrival he must bring the work to an immediate conclusion. There are now only six deficient parishes, and from the draconian colour of his ink any statistical delinquent may see what the rear rank has to look for. *Sat sapienti.* Whitehall, 11th July, 1797."

Apparently Sir John had access to the throne, as he indicates in some of his letters that His Majesty had expressed a personal interest in his project. He also sent copies of his prospectus to the Royal Courts of Europe, and in the twentieth Volume are reproduced replies which indicate the interest which this project aroused on the Continent.

The major portion of the work of editing the contributions from the various clergy was undertaken by Sinclair himself, but he was helped in this task by three well-known Edinburgh men, namely Sir Henry Moncrieff, Dr. Hardie and Mr. Walker of the Canongate.

Sinclair came in for some criticism in his use of the word "statistical." He indicates that many people were surprised at his using this new word as they supposed that some term in our own language might have expressed the same meaning. Sir John states that in the course of a very extensive tour through the northern parts of Europe which he made in 1786 he found that in Germany they were engaged on a species of political enquiry to which they had given the name "statistics." He himself applied a different idea to the word, for as he states, "by statistic is meant in Germany, an enquiry for the purpose of ascertaining the political strength of a country or questions respecting matters of state, whereas the idea I annex to the term is an enquiry into the state of a country for the purpose of ascertaining the quantum of happiness enjoyed by its inhabitants and the means of its future improvement. Yet as I thought a new word might attract more public attention I resolved on adopting it, and I hope that it is now completely naturalized and incorporated with our language." I am sure that members of the Royal Statistical Society will be interested to learn how the word "statistical" was introduced into the English language. The following facts indicate how the Second Statistical Account was initiated.

It would appear that Sinclair gave the profits of his Statistical Account to the Committee of the Society for the Sons and Daughters of the Clergy of the Church of Scotland, and if I may quote from the Report of this Committee to the General Assembly of the Church dated May, 1845: "This Society were led to engage in undertaking a Second Statistical Account by the circumstances of their having possessed the property of the First Account which was confided to them by its benevolent and public-spirited projector. This and the relation in which they stood to the Church seem to afford them an opportunity of doing a further service to the public by means of

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a new Account adapted to the present circumstances of the country. The proposal to obtain such an Account was first made to them by their Secretary, Sir Henry Jardine."

The General Assembly of the Church of Scotland approved of the new venture, and recommended the members of the Church to give all the aid in their power towards its completion. Apparently the Committee in charge of the new undertaking did not give the clergy quite the same voluminous series of questions to deal with in their respective reports. The main questions were divided under five headings—

(1) Topography and natural history,
(2) Civil history,
(3) Population,
(4) Industry,
(5) Parochial economy,

and under a sixth heading the local clergyman was requested to give his general observations.

Various subjects were suggested under the five headings. Under *Topography* and natural history, the name of the parish, its climate, geology, mineralogy and botany. Under *Civil history* information was requested in regard to the eminent men, chief landowners, particulars about parochial registers, as well as local objects of antiquarian and historical interest. The usual vital statistics were embraced under the third heading of *Population*, but as well as the subjects normally associated with vital statistics such subjects as local amusements, character of the people of the parish, and any special features for which the inhabitants were noted. Under the heading of *Industry*, the main subject dealt with was agriculture, but information was sought in regard to rent of land, value of raw produce and manufactures. Under the fifth heading—*Parochial economy*—the following were included: means of communication, education, state of the church, friendly societies, savings banks, poor and parochial funds.

As was the case in Sinclair's volumes, the most interesting portion of each account is usually to be found in the general observations of the parish minister himself, where he had scope to give his own views on the past, present and the probable future state of his parish.

The Second Statistical Account was started in 1832 and completed by the year 1845. The work was comprised in 52 numbers, which were issued regularly at intervals throughout that period. The accounts of the individual parishes were brought under their respective counties and were bound in 15 volumes, but individual accounts for each parish were published separately. In this Account it was intended at first to conclude the whole publication with a general summary of the more important facts which had been brought to light in the different branches of the enquiry, but in view of the summary which was appended to each county collection, and by the copious index which was prepared, the Committee deemed it unnecessary to issue any summary volume.

The actual number of words in the Second Account is over 50 per cent. greater than in the first.

It is difficult in the limited time at my disposal to compare the accounts of the individual parishes as they are given in the two investigations. In any case this is a task for the historian rather than for the actuary or the statistician. From an examination of the accounts of individual parishes in the two works, I would venture the following opinion: The First Account was the work of men of simple faith, who were concerned with small individual details of their own people and their own parish. Many examples are given of the miserable conditions under which the farm labourers lived, but warnings to the people are not lacking against the vice of extravagance and vanities of dress, particularly among women. In one parish, however, men are accused of vanity in wearing English hats instead of Kilmarnock bonnets for kirk and other dress occasions, and carrying watches in their fobs. The immoderate use of whisky is often the object of censure; but it is noticeable that tea drinking is regarded as not less mischievous.

It is observed in the earlier Account that the clergy make many references to ancient monuments, antiquities and archaeological remains, and that many instances are given of superstitious beliefs held by the people.

In the 40 odd years that elapsed between the two Accounts there was a great development in mechanical and scientific knowledge, and this is reflected in the type of information supplied by the compilers of the latter, in which the sciences of botany and geology bulk largely. Although railways had not extended into the remoter parts of the country, there were great developments in the means of transport in the first half of the 19th century, which made movement of the population much easier.

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There is much evidence in this report that the standard of life had materially improved during this period.

Having given these facts in regard to the two previous Statistical Accounts, I now proceed to indicate the steps which are being taken to inaugurate our present venture.

Through the generosity of the Nuffield Foundation we have been able to make a start. The plan which we have adopted is to undertake four preliminary surveys, each one being under the special supervision of one of the four Scottish Universities. Survey officers have been appointed by each University, and these officers are each responsible for one area. The four areas upon which we have made a start are the counties of Ayr, East Lothian and Fife—representing diverse types—and also the City of Aberdeen.

In so far as the counties are concerned the duties of these survey officers will be: First to inspire and direct the local people in each parish to prepare their own accounts, and second to themselves prepare a description of the county as a whole. The officer in charge of the city of Aberdeen will have to draw upon many sources of local knowledge and information in the preparation of the account of the city. These survey officers are under the general direction of the University representatives on the Central Statistical Account Committee.

It is hoped to complete these four preliminary surveys in the near future and from them we expect to obtain a valuable guide as to our further action. In the meantime, however, we are gathering at the centre information from parishes throughout the length and breadth of Scotland, and this information is being carefully filed and sifted, and will be of great use to us when the preparation of the reports for the other parts of Scotland come to be undertaken.

The previous reports had the powerful backing of the Church of Scotland, and while we have been fortunate in enlisting the sympathy of the Church we also envisage co-operation with secular bodies in our great task.

We hope to get, and indeed we have obtained, the goodwill of persons in all walks of life. We are endeavouring to make the parish Reports, not the opinions of a single individual, but the combined efforts of representative bodies of local opinions and views. We look to the goodwill of many national and local bodies in Scotland. We have been assured of the benevolent interest of the Secretary of State, and I am sure that help will not be lacking from the Scottish Departments of the Crown,

We propose in respect of each parish to give the local people a free hand in preparing the account of their own area in their own way. We will merely give them suggestions for headings under which the descriptions might be arranged. Generally, we propose that the following seven headings should form the basis of the individual accounts:

1. The Physical Basis.
2. History of the Local Community.
3. Population.
4. Public and Social Services.
5. Housing.
6. Agriculture, Industries and Commerce.
7. Way of Life.

We do not suggest that there should be a minute description of the physical basis of each parish, but any outstanding local feature should be dealt with in the parish account. Generally, although the parish will be the unit of study, we propose that parishes which form part of a geographical area and have common physical features should be described together. These groupings of parishes would be of value in cases where contiguous parishes have features common to each other in their history, in their local services and in their industry. We expect that these sets of groupings of related parishes will be published together as well as separately.

In the history of the local community we hope to obtain simple facts such as proverbial sayings, local customs and traditions, and possibly lists of words used only parochially. We would gather some information about unusual place names, also local ballads, medicinal cures or food recipes which are peculiar to the area under survey. In fact we hope to make the records intimate documents of the individual parishes.

We wish naturally to give some space to vital statistics, but we will not overload our publication with a mass of figures.

We shall record the changes which have taken place in the public and social services during

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the past century, and we expect to gather information about the various local organizations which indicate the way of life of the community.

Housing is a very important feature of the present day, and we hope to have some record of the present position of prospects for the future, and of changes which have taken place during the past century.

We shall gather information on the industries and commerce of the individual parishes, which in many cases will be mainly agricultural, and we hope that local methods of agricultural practice will be recorded.

Having noted all these facts, we wish to give a resumé of the way of life of the people to include the special or unique characteristics peculiar to the individual parish. I think our views on this point can best be summed up by giving an excerpt from a little pamphlet which the Scottish Council of Social Service have issued in connection with our project dealing with the vital matter of "*The way of life.*":

"The main task will be to describe not merely the physical facts, the public and social services, and the industries of the area, but to show how, in that environment and with those material conditions, the people live. We shall want to know not only about houses, but about family life, not only about churches, but about what religion means to people, not only about industries and products, but about the attitude of the people to work and leisure. We shall want to know of any significant changes that have occurred in customs, feelings and attitudes. And we shall want to know their hopes and prospects for the future."

I can imagine it being thought in some quarters that the taking of this Statistical Account is merely duplicating the work already accomplished by various Government Departments or by non-official organizations. Have not the Ministry of Labour undertaken many sample enquiries into the family and economic conditions of the insured population? Has the Board of Trade not instituted more than one census of production? Do not voluminous reports emanate from the offices of the Registrars-General? Are these official reports and compilations not supplemented by reports of the investigators engaged by the various social surveys? While all these questions can be answered in the affirmative, official reports and enquiries in the main deal with people in the mass, and the sample enquiries of the various social survey organizations deal with limited and special problems. Now as I have said, the conception of these Statistical Accounts of Scotland is to record the way of life of the people in their own surroundings, and we already have the incomparable record of life in country parishes in Scotland at the beginning of and half-way through the 19th century. Now we would record the way of life in individual parishes as we find it in the middle of this century, so that we shall have the data to enable us to measure the changes in the rural economy, and in the attitude of the people to the outstanding affairs of life.

We shall not be so much concerned with facts relating to the people in the mass such as are brought out by the census returns and Annual Reports of the Registrars-General, but we shall want to know the attitude of people to the problems of the day; how they amuse themselves; what is their attitude to religion, to sport and to communal life.

The changes which have taken place since the middle of last century are profound. Since the end of the Victorian era even the life of our people and their attitude to problems and affairs of the day has altered in almost every aspect. Had an enquiry such as we contemplate been taken at the end of last century we should have had a permanent record of the conditions and way of life at that time which may be forgotten for ever. In my journeys into the remoter parishes of Scotland I find that there is in practically every parish some person or body of persons well versed in the present conditions existing in their parish and the changes which have arisen in their life-time and I find much local enthusiasm for our project. It is my hope that we shall be able to record these facts and to utilise this enthusiasm. As I have stated, steps are being taken to gather a mass of material from all areas which will form the basis of our Account.

Now it may be thought that this is all very well as a record of facts and opinions, but what good is it going to be to the future well-being of the life of individual parishes and of Scotland as a whole. It seems to me that the information which we shall amass and the opinions which we shall gather will be of the greatest use in the future planning of the lives of our people. Unless we know the needs of particular areas we cannot meet them. While the primary purpose of our venture is social, it will afford the historian a true and intimate picture of Scotland as it was in the middle of this century of far reaching change.

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The demographic position of our northern country differs materially from that of England. If the age distribution of the two countries is compared, it is seen that not only do we in Scotland have a higher proportion of young children—due to our higher birth rate, mitigated alas by our higher infant death rate—but we have a smaller proportion of people over 50, more pronounced among males owing to our great loss by migration in the last century and in the first 30 years of this century (see Population distribution graphs). From 1901–1931 Scotland lost nearly one-quarter of the mean population. While we Scots are proud of the part our kinsmen have played in the building of our great Empire—and if I may say so, in building up the prosperity of England—we are poorer at home for this loss, and one can but hope that in years to come we will be able so to plan our economy that our own people may find work and happiness in their own native glens and on the uplands of our lowland counties. It is not generally realized, I think, that in the ten years ending in 1931, Scotland's net loss by migration was 392,000, against that of 172,000 for England and Wales. Scotland's loss was proportionately 16 times greater than that south of the border.

In our investigations we will find much diversity among the parishes of Scotland. In the central industrial belt there is great congestion of people recruited largely from the borders and the highlands. The age distribution of the industrial parishes is usually quite normal—the number living in each quinquennial age group after the 2nd being smaller than in the previous group. Very different, however, is the age constitution of the remoter parishes which have suffered heavily from migration to the towns and overseas. As examples of this diverse age distribution, I would instance the parish of Assynt and the industrial area of the county of Renfrew. (The population pyramids are given for the years 1861 and 1931.) In the highland parish it will be found that the population distribution at 1931 has ceased to be in the shape of a pyramid and has assumed that of a pillar. This maldistribution of the ages of the people living in the highlands must have a profound effect on the economy of life. Examination will show that in the industrial area, the age distribution of the population at 1931 was normal, apart from the reduction in the number of children under age 5, due to a drop in the birth-rate in the late twenties of this century.

In our investigation we will draw attention to these facts, and we hope as a result of our work to improve the economy of the depopulated areas. There is great geographical maldistribution of population in Scotland, which is evidenced by the fact that about four-fifths of our people live in approximately one-fourth of our area. In the county of Sutherland, which contains the parish of Assynt, there are fewer than seven persons to the square mile, but in Renfrew county the average square mile density is over 1,400.

It is well at this point of change in the world's evolution and in the history of our own land that we should chronicle the conditions of yesterday and of to-day, and from these observations endeavour to help our fellow countrymen so to arrange their way of life that the future may yield a full measure of happiness and prosperity to them. It is our aim to describe the people in their surroundings as we find them to-day, and to mark the changes which have taken place during the past century, to measure the effect which such changes have had on the way of life of the people, and to record their hopes and fears, their ideals and aspirations and to gauge their reactions to the conditions of life at present.

When Sinclair was President of the Board of Agriculture he attempted to inaugurate a Statistical Account for England, but I gather from contemporary writings that he met with opposition from the Church because of the questions he proposed to ask about ecclesiastical tithes. In fact no Statistical Account was taken on the same lines as those of Scotland, and in closing I would make the suggestion that this great Society might inaugurate and carry through a Statistical Account of England, and so record the condition of the country at a time when the whole life of the people is changing so rapidly and so profoundly.

Discussion on Mr. Kyd's Paper

Sir Sylvanus Vivian: I detached myself from the backwoods of retirement to attend this meeting and listen to my old colleague, whose fruitful co-operation I enjoyed throughout the war, and I have been given the privilege of moving a vote of thanks to him. The subject of his enter-

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prise is of the greatest interest, and looking back at the proposal originated by his illustrious predecessor, Sinclair, it appears to be most attractive. In many ways it differs greatly from the census. Censuses are limited to facts which can be established by statements not involving any element of degree and unaffected (so far as possible) by personal bias. We have steadily ejected from the census programme things like personal disabilities which are liable to the "more or the less" assessment according to the view of the person filling in the return, and have limited ourselves to matters capable of being more simply recorded. The intervals between the records are also far shorter than appears to be likely in the case of accounts of this sort. The distinctive character of these accounts is their universal range, including matters of opinion, tradition, and mental and moral outlook. Supposing for example that, century by century, in the past, we had had a series of parochial returns covering a wide range of subjects, it would be the sort of thing that the student of history in any form—social, political, natural, fiscal—is aching for. The Sinclair proposition might well provide similar records of very considerable range covering many and various events and circumstances.

If, however, one is considering the provision of facts which will be comparable with those regarded as of prime interest on an unknown future occasion, there is a dilemma which is felt by all authorities interested in records of every kind. No one knows at any time what will not be of interest to posterity, and no one dare make a selection on the strength of his own opinion or a corporate opinion as to what in the future will be considered as of exclusive importance. Therefore those who have the duty of providing for the future are bound to accept the principle of retaining everything, as the British Museum and the records Societies acknowledge. Mr. Kyd, in his Third Account, I gather, whilst retaining something of the generality of the field which is the most marked feature of Sinclair's proposal, does intend rather to concentrate on a particular type of interest, which he describes very fitly as the way of life. It embodies, I suppose, particulars not only of economic conditions, but of the general moral and intellectual attitude of the people to the prevailing circumstances, and the expression of their views on codes of morality and, perhaps, religion. That is a most important and valuable study, and I infer that the intention is to concentrate to some extent on that primary object rather than to distribute the function of the Account in an indifferent emphasis over a very large range of independent facts. I think that concentration is necessary.

There is just one point which no doubt Mr. Kyd has had in mind and on which I should like his opinion. Is he quite satisfied that the present is a suitable time for records which will take their place in a secular curve? It does seem to me that, particularly mentally and morally, the population of the whole country may undergo a considerable change, as it did after the previous war, from the outlook they have at present. But it is possible that the actual taking of the records and obtaining of the statements might be postponed until a time which would put it beyond that risk.

The other observation I venture to make arises out of Mr. Kyd's concluding words. I am not suggesting for a moment that an inquiry of the same sort would not be valuable in England and Wales as well as in Scotland; but my conviction—of an entirely unofficial kind—is that an Account of this sort requires an optimum population, and that Scotland is a good deal nearer the optimum population than England and Wales. Also the structure of England and Wales, possessing a larger number of dense homogeneous towns, presents some special difficulties. But these are mere observations thrown out on the spur of the moment, and I congratulate Dr. Kyd upon this interesting paper, and upon the great work he is undertaking in succession to his distinguished predecessors. I move a cordial vote of thanks.

Dr. Fraser Roberts: It has been a great pleasure to hear Mr. Kyd's interesting paper describing the previous Statistical Accounts of Scotland. The present proposal will provide a great deal of material and be of assistance in shaping policy. Scotland is, without doubt, an exceedingly suitable area for such an inquiry, largely because of the enthusiastic co-operation which will surely be forthcoming and for other reasons too, one of which has just been mentioned: that it is a unit of suitable size.

It has been suggested that the Society might like to hear a word about another national survey which was completed in Scotland earlier this month. In 1932 the Scottish Council for Research in Education carried out a survey in which they applied a group intelligence test to all children who were then 11 years old—87,000 in number. The results were published in 1933. Last year the Population Investigation Committee, in conjunction with the Scottish Council for Research in Education, suggested that it was time for this survey to be repeated. The possibility of doing so depends essentially on the generosity of the body mentioned by Mr. Kyd—the Nuffield Foundation—because the Population Investigation Committee was able to give financial support

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from money received from that source. On the fourth of this month, once again all the 11-year-old children were tested, using the same group intelligence scale as in 1932. The intention of the project was to see whether any evidence was forthcoming as to a possible decline in the intelligence of the population, such decline having been predicted on the ground of the well known association between intelligence and fertility. Actually the result may or may not produce evidence on this point, or the evidence may be difficult to interpret, but there is no doubt that the results of the survey will be valuable, because additional information is being secured. The information obtained on the schedules includes date of birth, place of domicile, position of child in family, possible and actual school attendance, and much else. For 10 per cent. of the sample, numbering over 8,000 children, a much more detail sociological inquiry has been instituted. This random sample consists of all the children born in 1936 whose dates of birth fell on one of the first three days of each calendar month. In addition there is a much fuller schedule for all twins—there should be about 1,000 pairs. Rather more than 1,000 children, those whose dates of birth fall on the first day of alternate months of the calendar year, are being given an individual test as well as the mass group test.

This body of data represents something quite unique. I do not think that anyone in the field of educational psychology has attempted so complete a survey. It might well be repeated at intervals of, say, half a generation—15 years. It would show very clearly what was happening to the intelligence levels of the population, and throw light on the factors which affect intelligence.

Another possible project which may be carried out is the follow-up of certain of these children to see what happens to them during the rest of their school career, and after they leave school and embark on adult life.

I doubt very much whether such a complete investigation on a nation-wide basis could be carried out in any other country. I have been struck again and again by the enthusiasm and thoroughness of all concerned, and by the truly amazing measure of co-operation secured from everybody—teachers, medical officers of health, official bodies, and others.

I will conclude by saying that it is a very great pleasure to second the vote of thanks to Mr. Kyd for so interesting a paper, and I am sure every Fellow of the Society wishes him every success in his venture.

The vote of thanks was put to the meeting and carried unanimously.

Mr. E. H. GODFREY joined with the proposer and seconder in supporting the vote of thanks to Mr. Kyd, who had expressed his views with great lucidity. He wished to say a few words about Sir John Sinclair and his work in this country, apart from the work he did for Scotland. He was for many years a member of the Imperial Parliament. When the war broke out against the French revolution in 1793 there developed in this country a very serious financial crisis, and an endeavour was made to restore the credit of the country by the issue of Exchequer bills. This was done on the recommendation of Sir John Sinclair, and it did a great deal towards the restoration of financial confidence. Pitt sent for Sinclair and expressed his obligation and asked what he could do for him. Sinclair replied that he had nothing to ask for for himself, but he desired Pitt's influence for the establishment in this country of a great national institution to be called the Board of Agriculture. The great agricultural economist of that day, Arthur Young, was very sceptical about the success of this movement, and there was a historical bet placed on record in which Young bet Sinclair nineteen volumes of his *Annals of Agriculture* against twenty-one volumes of the *Statistical Account of Scotland* that the project of the Board of Agriculture would not go through. He even wrote to Sinclair and said that Ministers would all be prepared to support industry and commerce, but never would they do anything for the plough. "Your Board of Agriculture," he wrote, "will be in the moon; if on earth remember I am to be the Secretary." But although Sinclair was not successful in introducing into this country a Statistical Account on the lines of that for Scotland, he did secure the institution by the Board of Agriculture —which was, after all, established—of a series of county reports throughout the whole of England. Those reports contained a great deal of interesting information about rural conditions, which would in any future account be of value for purposes of comparison and contrast.

Sir John Sinclair was a man of fine physical proportions—6 feet 2 inches, and athletic. There was the portrait of him by Raeburn to which Mr. Kyd had referred. The speaker had had something to do with editing the biography of Sinclair by his grandson, the late Archdeacon Sinclair of St. Paul's. The Archdeacon himself was a tall and distinguished looking man, and from him one could gain an idea of the appearance of his grandfather.

Mr. Kyd had referred to the introduction into our language of the word "statistics." Some of their older Fellows would be aware that this matter had been rather exhaustively studied,

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among others, by our colleague Mr. Udny Yule, and by the veteran statistician in the United States, Professor Willcox.

A suggestion was made that the Society should undertake an inquiry of the kind proposed by Mr. Kyd. He doubted whether the Society would be able to do anything in that direction unless it should happen to come into a very large sum of money from some extraneous source. But doubtless the Society would continue, as in the past, to give its support to enterprises of this kind. If such an inquiry were ever to be undertaken in this country it ought to be by the Government. There was now a Central Statistical Office, the institution of which body had long been advocated by Fellows of the Society. There was also before Parliament the Board of Trade's Statistics of Trade Bill, which might this session become an Act, and which provided for something like £90,000 annually for a census of production, for an occasional census of distribution, and for other inquiries which might perhaps be undertaken in conjunction with the Central Statistical Office. Possibly in ways such as these what was adumbrated by Mr. Kyd might be achieved.

Mr. A. M. STRUTHERS said that it might be of interest if he filled up some of the gaps which appeared in Mr. Kyd's paper. The first omission was that Mr. Kyd made no reference to the part which he himself had played in making these surveys possible. Towards the end of 1944 Mr. Kyd read a paper to the Royal Philosophical Society of Glasgow in which he suggested that a modern Statistical Account was desirable in view of the great changes which were taking place and the talk of reconstruction and planning which was in the air. He urged that it was desirable that right at the local level there should be an inquiry into and study of local traditions and other facts.

In Scotland they had a great respect for Mr. Kyd. They realized that he never said anything publicly without having given it very careful thought. Any statement by Mr. Kyd erred always on the side of caution. When he made his suggestion there were at once many bodies in Scotland which took up the question. People said that if Mr. Kyd thought it a good idea it was worth exploring. The Scottish Council of Social Service invited Mr. Kyd to discuss the matter with its Executive Committee. That discussion led to the setting up of a small committee of people expert in various fields for the purpose of examining the subject. It was an exploratory committee. After lengthy discussions and the preparation of eight draft reports—he himself was the unfortunate person who had to draft the eight reports—a memorandum was produced setting out the views of these people about the Statistical Account of Scotland. They considered it desirable, and then discussed what the limits of such a statistical account should be. Finally, in a few sentences they suggested a way in which this problem could be approached. The first step was that there should be a fairly large scale experiment, and that a study of three or four counties should be made. With that report they approached a number of public bodies in Scotland—the Church of Scotland, the Convention of Royal Burghs, the Association of County Councils in Scotland, the Association of Directors of Education, and so on. All these bodies indicated their willingness to give their support. Finally they went to the Universities, saying, "We are quite sure that there is a large body of influential support behind this idea in Scotland. Are the Universities prepared to co-operate?" The Universities of Scotland, like universities all over the world, were conservative bodies, and were also suffering from staff difficulties. They said, however, that they were prepared to do everything possible if the money could be found. At that point the Nuffield Foundation came on the scene and gave the money to enable the first four surveys to be undertaken. The four areas that were being surveyed were the City of Aberdeen (which was no mean city, of 170,000 people, with a great deal of variety, and not under the influence of any other large city) and three county areas. Ayrshire was possibly the most difficult of the survey areas; it had a population of over a quarter of a million, and within its borders there were two large burghs, both around the 40,000 mark, 14 small burghs, and 44 parishes. Then there was East Lothian, which had 7 small burghs and 24 parishes, but no large burghs. Fife was also difficult, being about the same size as Ayrshire in population, with two large burghs, 26 small burghs, and 66 parishes, and thus involved the making of some 94 Accounts.

For these pilot surveys each university appointed a survey officer. For Glasgow, which was undertaking Ayrshire, a consultant was appointed as well as the survey officer. The survey officers were working as a team. The Scottish Council of Social Service had provided a secretariat, and a member of their staff devoted her time to co-ordinating the work of the survey officers. Of the survey officers one was a geographer, two were economists, one was an educationist, and the fifth a historian, so that there was a wide field of experience amongst them. They met every month for two or three days together, and they had divided up certain parts of the work. The general planning and framework of county accounts had been decided, and the preparation of

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question sheets undertaken. Each parish would be provided with lists of questions on the subject matter on which information was to be collected.

This central organization had functioned very satisfactorily. From month to month the survey officers had been exchanging information and dividing up the work, and also at these meetings they had been able to draw on the experience of particular fields. At the county level they had been in touch with the public authorities, with the county council and its officers, and with the county branches of the Educational Institute. They had also been in touch with the presbyteries as representing the Church of Scotland. Every minister throughout each survey area had received a circular from his presbytery asking him to co-operate. Similarly the headmaster of every school had received a circular from the Director of Education, and every teacher had been asked by the Educational Institute to do what he or she could to help the survey. The result was that in all the parishes and areas there were groups and committees at work collecting information. One of the by-products already appearing was that far more material was being collected locally than would actually go into any Account. The average size of the parish Account would be about 4,000 words; but many of the local committees had decided that they would prepare a book of their own parish in which a great deal of the information collected would be put on permanent record. and that would be of very great importance to planning officers, to sociologists, and to all sorts of people who were interested in the life of local communities.

He had covered some of the points which were omitted from Mr. Kyd's address, and which might be of interest to the members.

Professor M. GREENWOOD joined with other speakers in expressing hopeful interest in this plan. He felt that medical practitioners and medical officers of health in Scotland were in a good position to make judgments as to the state of the community, and he had not noticed in the last speaker's account of the work of the supervisory committee any person mentioned as having medical knowledge.

Another point which occurred to him was that it was not clear that a resident was the best recorder. Take, for example, Boswell's account of the tour of the Hebrides, which everybody had read, and Johnson's account, which comparatively few people had read. He had read the latter twice, and would say that it told one a great deal more about Scotland than Boswell's account did, for the rather obvious reason that Boswell did not describe things which every Scot knew about, or thought he knew about, whereas an intelligent outsider like Johnson noticed them. The best observer, or at all events the best narrator, was probably someone who did not live in the locality. He hoped that Mr. Kyd would not be disappointed if the work was rather unequal. When it came to an intimate and graphic account of the lives of people it needed an artist, perhaps a genius, to give it. He thought it possible that more might be learnt from *Guy Mannering* about the lives of Lowlanders in the 18th century than from Sir John Sinclair's informants.

One of the speakers had referred to Sir John Sinclair himself. The original Account, if one was rich enough to possess it or could borrow it from the Society's library, was one of the best possible bed books. One anecdote of Sir John Sinclair was told in Trevelyan's *Life of Macaulay*. Sinclair was president of the Board of Agriculture and thought this was a very important post. Accordingly he wrote a letter to the Prime Minister, Pitt, in which he said that he thought the President of the Board of Agriculture should be a peer. After a short interval he received a letter back from Mr. Pitt saying that, on the whole, he agreed, and was accordingly accepting Sir John's resignation and putting Lord Somerville in his place! Unfortunately Sinclair, who had not the art of telling with humour a story against himself, did tell it, and showed great indignation. He said it was such a "wilful misunderstanding."

Mr. KYD said that he had no intention of making a formal reply, but he would be very discourteous if he did not express his great indebtedness to those Fellows and guests who had spoken on the paper. He was particularly grateful to his colleague, Sir Sylvanus Vivian, for what he had said; he was interested in Mr. Godfrey's remarks about Sinclair, and in Professor Greenwood's useful comments. Professor Greenwood might rest assured that the help of the local doctors would be sought, also that of the district nurses. Mr. Struthers had filled in a number of omissions from the summary of his paper, but he thought that if the Society deemed it worthy of printing in the *Journal* they would find that most of the points had been covered. He had been interested also in the pleasant things that Dr. Roberts had said about Scotland. He had had the privilege of having had contacts with Professor Godfrey Thomson in his work in Edinburgh, and it was always a great pleasure to be of any assistance in a scientific investigation concerning the intelligence of Scottish children.

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As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Maurice Henry Belz, B.Sc., M.Sc., M.A.
John Brown, M.A.
Geoffrey Cowlin, B.Sc.(Econ.).
Roy Henry Garstang, B.A.,
Keith Meredith Johnson.
Ralph Charles Bradley Lane, M.A., B.Sc., F.I.A.
Justin McCarthy Power, B.A.
Eric William Napier Ratcliff.
Stanley Rushton, M.A., B.Sc.,
Gamal El-Dine Mohamed Ahmed Said, B.Sc., M.Com., Ph.D.
Alfred Sapsford, B.Sc.(Econ.).
Jack Stafford, M.A.
Herbert John Thrift, B.Sc.(Econ.).
William Whitehead, M.A., F.F.A.
Frank Henry Willis.

Corporate Representative

Lionel R. McColvin, representing the City of Westminster Public Libraries.

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Wholesale Prices in 1946

By the Editor of "The Statist"

Table I

The Statist's *Annual Index Numbers* (*in continuation of Sauerbeck's figures*) (1867–77 = 100)

Year	Average No.	Year	Average No.	Year	Average No.	Year	Average No.	Year	Average No.
1946	186	1925	136	1904	70	1884	76	1864	105
'45	164	'24	139	'03	69	'83	82	'63	103
'44	160	'23	128	'02	69	'82	84	'62	101
'43	155	'22	131	'01	70	'81	85	'61	98
'42	151	'21	155	'00	75	'80	88	'60	99
'41	142	'20	251	1899	68	'79	83	'59	94
'40	128	'19	206	'98	64	'78	87	'58	91
'39	94	'18	192	'97	62	'77	94	'57	105
'38	90	'17	175	'96	61	'76	95	'56	101
'37	102	'16	136	'95	62	'75	96	'55	101
'36	88	'15	108	'94	63	'74	102	'54	102
'35	83	'14	85	'93	68	'73	111	'53	95
'34	81	'13	85	'92	68	'72	109	'52	78
'33	78	'12	85	'91	72	'71	100	'51	75
'32	79	'11	80	'90	72	'70	96	'50	77
'31	82	'10	78	'89	72	'69	98	'49	74
'30	96	'09	74	'88	70	'68	99	'48	78
'29	114	'08	73	'87	68	'67	100	'47	95
'28	119	'07	80	'86	69	'66	102	'46	89
'27	122	'06	77	'85	72	'65	101	'18	159*
'26	125	'05	72					'10	171*

* Jevon's numbers adjusted.

Table II

The Statist's *Annual Index Numbers—ten-year averages* (1867–77)

1848–1857 = 89	1899–1908 = 72	1913–1922 = 153	1927–1936 = 95
'58– '67 = 99	1900– '09 = 73	'14– '23 = 157	'28– '37 = 93
'68– '77 = 100	'01– '10 = 73	'15– '24 = 162	'29– '38 = 90
'78– '87 = 79	'02– '11 = 74	'16– '25 = 165	'30– '39 = 88
'88– '97 = 67	'03– '12 = 76	'17– '26 = 164	'31– '40 = 91
'90– '99 = 66	'04– '13 = 77	'18– '27 = 159	'32– '41 = 97
'91–1900 = 66	'05– '14 = 79	'19– '28 = 152	'33– '42 = 104
'92– '01 = 66	'06– '15 = 82	'20– '29 = 142	'34– '43 = 111
'93– '02 = 66	'07– '16 = 88	'21– '30 = 127	'35– '44 = 119
'94– '03 = 66	'08– '17 = 98	'22– '31 = 120	'36– '45 = 127
'95– '04 = 67	'09– '18 = 110	'23– '32 = 115	'37– '46 = 137
'96– '05 = 68	'10– '19 = 123	'24– '33 = 110	
'97– '06 = 70	'11– '20 = 146	'25– '34 = 104	
'98– '07 = 71	'12– '21 = 148	'26– '35 = 99	

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*Monthly Fluctuations of the Index Numbers * of 45 Commodities, 1867–77 = 100*

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1898 . .	62·8	63·4	63·0	65·5	66·4	64·7	64·3	64·0	63·9	63·6	63·9	63·8	64
1900 . .	74·0	75·1	75·7	75·6	75·5	75·7	76·2	76·0	75·5	74·7	73·9	73·4	75
'01 . .	72·2	71·7	71·0	70·6	70·5	69·8	69·5	69·8	69·6	69·6	69·0	68·4	70
'02 . .	68·8	68·9	69·2	69·7	70·9	70·4	70·0	69·5	69·3	68·8	68·6	69·1	69
'03 . .	69·5	70·2	70·4	69·4	69·6	69·5	69·5	70·0	69·1	69·0	69·0	70·0	69
1904 . .	70·4	70·8	70·8	70·5	69·9	69·4	69·9	70·4	70·7	71·0	71·2	70·9	70
'05 . .	71·2	71·4	71·8	72·0	71·7	72·0	72·5	72·3	72·4	73·2	74·2	74·9	72
'06 . .	75·2	75·0	75·7	76·5	77·0	76·9	76·4	76·7	77·5	78·5	78·6	79·7	77
'07 . .	80·0	80·7	80·0	80·7	82·4	82·0	81·1	79·4	79·1	78·8	76·7	76·2	80
'08 . .	76·0	74·5	74·1	73·8	73·6	72·9	73·1	72·2	72·5	72·2	72·2	72·3	73
1909 . .	72·0	71·9	72·4	74·3	75·4	75·1	75·2	74·9	74·7	75·2	75·5	76·3	74
'10 . .	77·1	78·1	79·1	78·5	78·2	76·9	78·1	78·2	77·6	77·2	77·8	77·9	78
'11 . .	78·5	78·6	78·9	80·0	80·3	80·0	78·9	79·5	80·3	80·7	80·6	80·9	80
'12 . .	81·8	82·9	84·4	85·0	85·3	85·5	86·5	85·9	86·7	85·8	85·3	86·4	85
'13 . .	86·4	86·1	86·7	86·2	85·7	84·1	84·2	85·0	85·7	84·5	83·3	83·8	85
1914 . .	83·5	83·8	82·8	82·3	82·3	81·2	82·4	87·9	89·3	89·8	88·8	91·6	85
'15 . .	96·4	100·9	103·7	105·9	107·2	106·4	106·4	107·0	107·8	110·0	113·1	118·4	108
'16 . .	123·6	127·0	130·4	134·2	135·4	131·0	130·5	134·5	134·4	141·5	150·8	154·3	136
'17 . .	159·3	164·0	169·0	173·0	175·0	180·4	176·9	175·7	176·4	180·6	182·9	185·1	175
'18 . .	186·2	187·3	188·0	189·8	191·1	192·3	192·9	195·9	197·1	197·8	195·3	196·0	192
1919 . .	192·1	187·5	184·7	184·6	194·6	199·4	206·4	212·7	214·8	224·3	231·0	235·2	206
'20 . .	245·3	260·4	261·8	266·1	260·0	255·7	254·6	253·5	248·7	239·9	223·8	207·2	251
'21 . .	197·2	183·0	177·2	169·8	162·2	155·8	158·2	154·3	149·4	138·4	136·7	133·6	155
'22 . .	132·5	132·2	133·3	134·8	135·5	135·6	134·0	129·6	127·9	130·1	130·6	129·1	131
'23 . .	130·2	131·9	132·7	134·0	132·2	127·9	124·8	125·0	127·8	127·7	132·4	133·2	128
1924 . .	137·2	138·8	137·0	136·8	136·4	136·3	138·4	138·0	141·3	146·1	145·5	147·7	139
'25 . .	144·8	143·1	140·1	137·5	135·7	131·2	134·3	134·3	132·7	130·2	132·9	130·4	136
'26 . .	129·3	127·9	126·1	125·5	125·7	124·9	126·0	127·0	128·0	131·0	130·8	123·9	125
'27 . .	123·1	124·1	123·6	123·3	123·8	123·1	122·0	122·8	121·5	120·6	121·5	121·4	122
'28 . .	120·9	121·1	123·6	125·6	126·2	122·6	120·3	118·0	116·8	116·8	117·9	117·9	119
1929 . .	117·0	120·1	120·5	116·5	113·0	113·1	115·2	113·9	112·6	111·1	108·3	108·8	114
'30 . .	106·6	104·8	103·0	101·5	98·8	95·8	94·4	92·2	90·8	90·4	88·6	86·9	96
'31 . .	85·7	85·5	85·5	84·4	82·2	82·6	80·2	79·1	80·7	82·3	83·0	85·4	82
'32 . .	84·7	86·7	84·1	82·5	80·2	77·0	78·9	80·7	80·4	77·8	77·9	77·7	79
'33 . .	77·8	77·0	77·0	78·5	80·9	81·3	81·7	81·2	80·7	80·5	79·3	80·0	78
1934 . .	82·5	82·5	82·2	81·0	81·1	80·7	82·4	83·4	82·1	81·1	81·0	82·8	81
'35 . .	83·6	83·4	82·9	84·1	85·2	83·7	84·3	84·1	85·1	85·8	86·3	86·7	83
'36 . .	87·1	87·1	86·7	86·2	85·6	84·8	87·1	89·0	90·4	91·7	94·5	98·9	88
'37 . .	99·6	102·1	107·3	104·7	106·2	104·7	105·9	104·4	103·3	100·8	96·7	97·3	102
'38 . .	96·5	96·4	94·2	93·5	91·4	91·4	91·1	88·6	88·6	88·8	87·4	89·1	90
1939 . .	88·7	88·6	89·0	90·5	90·6	90·6	88·7	90·4	99·7	105·8	112·2	120·1	94
'40 . .	124·1	124·5	123·4	126·0	128·0	130·0	129·5	131·5	131·6	131·8	132·7	134·5	128
'41 . .	134·9	136·3	138·0	141·1	143·5	144·4	145·3	145·1	145·5	143·7	145·5	146·5	142
'42 . .	148·6	153·4	153·5	154·5	156·6	154·4	150·0	149·4	149·7	150·4	151·3	152·2	151
'43 . .	153·3	153·2	154·0	154·9	155·6	155·4	156·0	154·4	154·6	153·7	153·9	153·9	155
1944 . .	154·9	155·1	155·7	157·9	159·5	160·0	161·9	161·5	160·1	159·6	160·3	160·7	160
'45 . .	161·4	161·5	162·1	162·4	164·0	166·7	165·2	163·3	162·7	162·7	162·7	163·2	164
'46 . .	165·6	166·2	166·6	168·4	169·3	169·7	174·4	175·7	180·5	196·2	198·1	200·5	186
'47 . .	206·7	209·6	212·1	215·9	216·5	218·1	223·4	225·9	228·9	236·0	240·8	246·5	

* The average of the twelve monthly figures of each year does not necessarily coincide with the annual figures, as the latter are calculated mostly from the average of 52 weekly quotations, while the former are based on end-of-the-month prices.

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Summary of Index Numbers. Groups of Articles, 1867–77 = 100

	Vegetable Food (Corn, etc.)	Animal Food (Meat, etc.)	Sugar, Coffee, and Tea	Total Food	Minerals	Textiles	Sundry Materials	Total Materials	Grand Total	Silver*	Wheat Harvest †	Average Price of Consols ‡	Average Bank of England Rate ‡
												£	%
1873	106	109	106	107	141	103	106	114	**111**	97·4	80	92½	4·750
1896	53	73	59	62	63	54	63	60	**61**	50·5	112	110¾	2·483
1911	70	90	61	75	93	76	81	83	**80**	40·4	110	79 5/16	3·467
1918	168	207	130	174	192	222	202	206	**192**	76·4	111	56 7/8	5·0
'19	179	213	147	185	220	228	219	222	**206**	85·3	98	54 1/2	5·166
'20	227	263	198	234	295	262	244	264	**251**	76·1	96	47 1/16	6·71
'21	143	218	83	158	181	140	145	153	**155**	48·1	118	47 3/16	6·092
1922	107	184	82	130	142	134	122	131	**131**	51·6	105	56 1/32	3·692
'23	98	162	101	122	155	140	115	133	**128**	49·4	105	57 3/16	3·496
'24	119	158	105	130	158	170	119	145	**139**	50·7	107	56 3/4	4·0
'25	118	162	89	128	154	165	117	142	**136**	52·5	114	56 3/8	4·575
'26	108	150	88	119	154	133	112	130	**125**	47·1	99	54 3/16	5·0
1927	108	138	83	114	141	131	116	127	**122**	42·8	109	54 3/8	4·650
'28	107	142	78	114	123	136	114	123	**119**	44·0	109	55 1/16	4·5
'29	99	146	72	110	126	122	108	117	**114**	40·2	114	54 5/16	5·508
'30	77	142	54	96	112	84	94	96	**96**	29·0	99	56	3·4
'31	68	119	50	83	100	63	81	80	**82**	20·4	99	55 1/16	3·975
1932	72	105	50	79	99	64	78	80	**79**	19·5	105	66 3/32	3·017
'33	60	106	47	74	107	67	76	82	**78**	18·7	114	73 3/32	2·0
'34	63	108	50	77	109	72	76	84	**81**	20·0	120	80 1/32	2·0
'35	66	107	42	76	112	80	79	88	**83**	26·4	112	86½	2·0
'36	76	109	41	81	118	83	84	93	**88**	18·5	100	85 11/64	2·0
1937	93	117	49	93	142	93	98	109	**102**	18·4	99	76 9/32	2·0
'38	81	111	43	84	136	75	83	95	**90**	17·6	122	74 5/32	2·0
'39	74	115	47	83	137	93	88	102	**94**	17·1	112	66 21/64	2·5
'40	112	141	58	111	167	149	117	140	**128**	17·1	108	72 9/16	2·0
'41	140	142	65	125	181	162	131	154	**142**	18·0	109	79 13/16	2·0
1942	170	148	66	140	184	163	142	160	**151**	18·1	123	82 5/16	2·0
'43	156	156	72	138	187	166	156	167	**155**	18·1	123	80¾	2·0
'44	152	156	73	137	197	182	161	178	**160**	18·1	121	80 5/32	2·0
'45	155	156	78	139	209	189	159	182	**164**	23·1	—	87 3/16	2·0
'46	155	154	88	140	239	231	198	219	**186**	36·7	—	95 13/32	2·0
Average													
1904–13	68	91	53	73	95	74	76	81	**77**	44·1	106	82 5/32	3·733
1890–99	61	80	63	68	71	56	66	64	**66**	55·8	103	103 1/16	2·958
'78–87	79	95	76	84	73	71	81	76	**79**	82·1	97	99 1/16	3·264
1818–27	109	90	151	111	128	105	106	112	**111**	98·0	—	—	3·692

* Silver (see note on p. 386), parity of 1 gold to 15½ silver = 100.

† Wheat harvest in U.K. to 1895: 29 bushels = 100; from 1896: 30 bushels = 100.

‡ Average price of Consols and the average Bank of England rate of discount are actual figures, not index-numbers: Consols 3% to 1888, 2¾% from 1889, 2½% from April, 1903.

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THE STATIST'S *Index Numbers—monthly average by groups*, 1867–77 = 100

	Vegetable Food	Animal Food	Sugar, Tea, and Coffee	Food-stuffs	Minerals	Textiles	Sundry Materials	Total Materials	All Commodities
1944									
Jan.	151·2	155·7	74·1	136·6	190·1	160·8	159·4	168·1	154·9
Feb.	151·8	155·7	72·9	136·6	191·4	160·9	159·2	168·4	155·1
Mar.	151·9	155·7	74·2	137·0	192·8	161·6	160·1	169·3	155·7
April	151·9	155·7	74·5	137·0	192·3	178·3	156·9	173·2	157·9
May	151·9	155·7	74·3	137·0	194·3	180·2	161·2	175·9	159·5
June	151·5	155·7	74·7	136·9	194·2	181·5	162·6	176·9	160·0
July	156·5	155·7	75·6	139·2	194·8	182·2	165·5	178·5	161·9
Aug.	149·9	155·7	77·4	136·8	197·8	184·1	164·5	179·5	161·5
Sept.	150·3	155·7	74·4	136·3	205·3	184·9	154·3	177·5	160·1
Oct.	150·3	155·7	73·7	136·2	203·9	184·1	154·3	176·8	159·6
Nov.	151·4	155·7	74·0	136·7	205·0	184·1	155·4	177·6	160·3
Dec.	152·6	155·7	73·5	137·1	202·9	185·5	156·7	178·0	160·7
1945									
Jan.	153·8	155·7	73·8	137·6	203·4	185·5	158·2	178·8	161·4
Feb.	154·2	155·7	73·2	137·7	204·4	185·5	157·9	178·9	161·5
Mar.	156·3	155·7	74·2	138·8	206·6	187·0	155·9	179·1	162·1
April	153·0	155·7	74·5	137·5	205·5	189·7	158·3	180·7	162·4
May	158·3	155·7	74·8	139·8	209·1	189·8	158·3	181·6	164·0
June	170·1	155·7	74·4	144·6	213·5	189·8	158·4	182·9	166·7
July	162·3	155·7	72·2	140·9	213·5	189·8	158·4	182·9	165·2
Aug.	155·5	155·7	74·6	138·5	211·9	189·6	155·8	181·3	163·3
Sept.	154·4	155·7	74·6	138·1	212·0	189·6	154·3	180·7	162·7
Oct.	154·1	155·7	73·5	137·8	212·3	190·1	154·2	180·9	162·7
Nov.	155·0	155·7	74·5	138·3	212·6	190·0	153·0	180·4	162·7
Dec.	155·0	155·7	75·3	138·5	211·5	190·0	155·6	181·2	163·2
1946									
Jan.	155·4	155·7	77·8	139·2	225·8	190·4	155·0	184·6	165·6
Feb.	155·6	155·7	79·6	139·6	225·5	192·0	155·4	185·5	166·2
Mar.	156·1	155·7	78·5	139·6	225·3	192·0	157·2	186·3	166·6
April	157·9	155·7	78·5	140·4	230·6	192·0	160·1	188·8	168·4
May	156·7	153·6	82·3	139·9	230·6	196·1	161·4	190·7	169·3
June	157·0	153·6	82·1	140·0	231·6	197·2	161·4	191·4	169·7
July	160·7	153·6	84·2	141·9	241·3	207·7	163·7	198·1	174·4
Aug.	153·1	154·7	85·2	139·4	247·5	209·1	167·7	201·9	175·7
Sept.	154·2	154·7	84·0	139·6	256·7	218·1	175·3	210·3	180·5
Oct.	154·4	154·7	85·9	140·1	257·8	269·5	200·6	237·2	196·2
Nov.	151·6	154·7	85·6	138·8	261·7	271·7	206·4	241·4	198·1
Dec.	152·9	154·7	89·2	140·1	263·1	275·7	210·6	244·2	200·5
1947									
Jan.	156·0	154·7	91·1	141·9	277·5	287·6	215·1	254·2	206·7
Feb.	156·0	154·7	92·0	142·0	280·1	287·6	224·8	258·9	209·6
Mar.	156·1	154·7	91·2	141·9	291·0	284·9	230·4	263·5	212·1
April	157·3	154·7	93·7	143·0	289·7	284·1	245·5	269·2	215·9
May	158·1	148·1	101·0	142·4	288·4	285·1	249·0	270·7	216·5
June	173·5	148·1	99·4	148·6	288·7	284·2	245·1	268·9	218·1
July	182·0	148·1	100·9	152·3	293·1	292·9	251·0	275·2	223·4
Aug.	188·5	148·1	102·4	155·5	293·3	297·1	253·0	277·4	225·9
Sept.	190·9	144·0	103·2	155·1	299·9	303·9	256·8	282·9	228·9
Oct.	196·5	144·0	102·9	157·5	311·2	320·7	262·6	293·6	236·0
Nov.	201·8	144·0	104·1	160·0	315·9	328·2	269·2	299·9	240·8
Dec.	204·2	144·0	102·1	160·5	340·9	333·2	271·6	309·2	246·5

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Quarterly Movements of Prices *

Summary of Index Numbers, 1867–77 = 100

Years	Quarters	Vegetable Food (Corn, etc.)	Animal Food (Meat, etc.)	Sugar, Coffee, and Tea	Total Food	Minerals	Textiles	Sundry Materials	Total Materials	Grand Total	Silver †
'35	I	64·4	111·2	41·3	76·8	108·9	77·4	82·6	88·0	**83·3**	23·0
	II	67·1	107·9	42·3	76·9	112·3	79·4	82·8	89·8	**84·3**	29·3
	III	68·8	106·6	40·6	76·8	113·8	80·1	82·3	90·1	**84·5**	27·3
	IV	70·7	104·1	41·8	76·9	116·7	83·6	84·9	93·0	**86·3**	25·7
'36	I	72·1	104·6	41·2	77·6	116·1	84·6	86·4	93·8	**87·0**	18·2
	II	71·2	107·1	39·7	77·8	114·7	79·4	84·8	91·2	**85·5**	18·6
	III	75·3	112·6	39·1	81·5	116·7	80·5	90·0	94·2	**88·8**	18·6
	IV	85·8	110·7	42·6	85·9	129·6	88·2	93·8	101·7	**95·0**	18·9
'37	I	93·1	112·7	47·1	90·6	144·3	97·4	102·3	112·0	**103·0**	18·6
	II	94·3	121·0	49·6	94·7	143·5	99·9	102·9	112·8	**105·2**	18·7
	III	93·3	121·4	50·2	94·6	147·7	94·6	101·4	111·8	**104·5**	18·4
	IV	95·5	116·3	47·2	93·0	136·3	81·2	95·6	102·1	**98·3**	18·0
'38	I	92·3	116·4	43·1	90·8	134·8	77·8	92·4	99·3	**95·7**	18·5
	II	89·2	114·1	42·2	88·5	132·0	73·5	86·5	94·8	**92·1**	17·4
	III	78·0	107·4	42·9	81·4	135·9	73·9	85·0	95·3	**89·4**	17·3
	IV	68·8	105·8	43·3	77·1	140·6	74·3	85·1	96·7	**88·4**	17·4
'39	I	68·0	110·9	43·5	78·7	134·2	79·6	84·0	96·2	**88·8**	17·7
	II	66·7	112·9	46·9	79·6	134·4	85·7	85·3	98·7	**90·6**	17·3
	III	65·2	117·0	48·1	80·7	135·8	91·1	88·0	101·8	**92·9**	15·7
	IV	93·2	130·3	57·4	99·3	146·7	123·5	106·4	122·5	**112·7**	17·8
'40	I	104·2	141·2	57·4	108·0	160·1	141·2	116·1	135·6	**124·0**	16·3
	II	108·0	140·5	56·7	109·2	165·2	148·4	122·2	141·8	**128·0**	16·7
	III	117·3	140·5	58·6	113·5	171·1	148·6	122·2	143·4	**130·9**	17·6
	IV	127·5	140·5	58·8	117·8	173·5	151·9	119·8	144·1	**133·0**	17·9
'41	I	129·8	141·3	61·9	119·8	179·0	154·8	124·7	148·6	**136·4**	18·0
	II	137·9	142·8	65·3	124·4	181·2	161·6	137·2	156·6	**143·0**	18·0
	III	145·0	142·8	65·4	127·4	181·0	165·6	138·5	158·3	**145·3**	18·0
	IV	151·0	142·8	68·9	130·7	181·6	163·1	134·2	155·8	**145·2**	18·1
'42	I	179·6	144·3	69·3	143·4	181·6	161·1	140·6	157·9	**151·8**	18·1
	II	188·6	147·3	69·5	148·3	182·2	160·4	146·1	160·2	**155·2**	18·1
	III	158·4	147·3	71·4	136·0	185·8	158·3	144·1	159·7	**149·7**	18·1
	IV	156·6	151·1	71·4	136·7	186·8	164·9	145·0	162·0	**151·3**	18·1
'43	I	159·1	155·7	72·8	139·7	188·0	163·9	148·4	163·8	**153·5**	18·1
	II	159·9	155·7	73·1	140·1	188·3	165·1	153·5	166·4	**155·3**	18·1
	III	156·1	155·7	74·1	138·7	188·2	163·4	156·0	166·9	**155·0**	18·1
	IV	150·1	155·7	74·2	136·2	187·8	160·8	157·4	166·6	**153·8**	18·1
'44	I	151·6	155·7	73·7	136·7	191·4	161·1	159·6	168·6	**155·2**	18·1
	II	151·8	155·7	74·5	137·0	193·9	180·0	160·2	175·3	**159·1**	18·1
	III	152·2	155·7	75·8	137·4	199·3	183·7	161·4	178·5	**161·2**	18·1
	IV	151·4	155·7	73·7	136·7	203·9	184·6	155·4	177·5	**160·2**	18·1
'45	I	154·8	155·7	73·7	138·0	204·8	186·0	157·3	178·9	**161·7**	19·6
	II	160·5	155·7	74·6	140·6	209·4	189·8	158·3	181·7	**164·4**	19·5
	III	157·7	155·7	73·8	139·2	212·5	189·7	156·2	181·6	**163·7**	20·2
	IV	154·7	155·7	74·4	138·2	212·1	190·0	154·3	180·8	**162·9**	31·1
'46	I	155·7	155·7	78·6	139·4	225·5	191·5	155·9	185·5	**166·1**	31·1
	II	157·2	154·3	81·0	140·1	230·9	195·1	160·9	190·3	**169·1**	31·1
	III	156·0	154·3	84·5	140·3	248·5	211·6	168·9	203·4	**176·9**	38·2
	IV	153·0	154·7	86·6	139·7	260·9	272·3	205·9	240·9	**198·3**	41·6

* The averages of the four quarterly figures to each year do not necessarily coincide with the annual averages, as the latter are based as far as possible on average weekly prices. See also the *Journal*, 1893, p. 221; 1895, p. 144; 1901, p. 90; and 1909, p. 70.

† Silver, parity of 1 gold to 15½ silver = 100.

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Construction of the Tabular Statements

The following table illustrates the method of construction of the index numbers. The index numbers here given are based on the average prices for the eleven years 1867–77. Take, for instance, the *Gazette* price of English wheat:

		s.	*d.*			
Average, 1867–77	54	6	= 100, average point.			
,, 1914	35	0	= 64, or 36 per cent.	*below*	the average point.	
,, 1930	80	7	= 148, ,, 48	,,	*above*	,, ,,
,, 1936	53	3	= 98, ,, 2	,,	*below*	,, ,,

The individual index numbers, therefore, represent simple percentages of the average point. The articles are grouped in six categories:

	Index Nos.	1867–77 Total Numbers	Example for 1946	
			Total Numbers	Average
1. Vegetable food, corn, etc. (wheat flour, barley, oats, maize, potatoes, and rice)	8	800	1,239	155
2. Animal food (beef, mutton, pork, bacon, and butter)	7	700	1,078	154
3. Sugar, coffee, and tea	4	400	352	88
1–3. *Food*	19	1,900	2,669	140
4. Minerals (iron, copper, tin, lead, and coal)	7	700	1,671	239
5. Textiles (cotton, flax, hemp, jute, wool, and silk)	8	800	1,848	231
6. Sundry materials (hides, leather, tallow, oils, soda, nitrate, indigo, and timber)	11	1,100	2,177	198
4–6. *Materials*	26	2,600	5,696	219
General Average	45	4,500	8,365	186

The general average is drawn from all forty-five descriptions which are treated as of equal value, and is the simple arithmetic mean as shown above.

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Index of Silver Prices

The base of the index numbers given below is 60·84*d.* per standard oz. = 100, this being a parity of 1 fine oz. of gold to 15½ standard ozs. of silver.*

	Price per oz. standard	Index number		Price per oz. standard	Index number
	d.			*d.*	
Average 1873	59¼	=97·4	*Lowest* Nov., 1902	21 11/16	=35·6
,, '90–99	34	=55·8	End Dec., 1906	32 5/16	=53·1
,, 1917–26	40½	=66·6	,, Dec., '08	23 3/16	=38·1
,, 1893	35⅝	=58·6	,, Dec., '12	29	=47·7
,, '96	30¾	=50·5	,, Dec., '13	26 9/16	=43·7
,, 1914	25 5/16	=41·6	,, Dec., '14	22 11/16	=37·3
,, '15	23 11/16	=38·9	,, Dec., '15	26¼	=43·1
,, '16	31 5/16	=50·4	,, Dec., '16	36½	=58·7
,, '17	40⅞	=65·8	,, Dec., '17	43½	=70·0
,, '18	47½	=76·4	,, Dec., '18	48 7/16	=77·9
,, '19	57	=85·3	,, Dec., '19	77¼	=98·3
,, '20	61 9/16	=76·1	,, Dec., '20	40⅞	=49·2
,, '21	36⅞	=48·1	,, Dec., '21	34⅝	=49·3
,, '22	34 7/16	=51·6	,, Dec., '22	31 9/16	=49·6
,, '23	31 15/16	=49·4	,, Dec., '23	33 7/16	=49·0
,, '24	34	=50·7	,, Dec., '24	31 13/16	=50·4
,, '25	32⅛	=52·5	,, Dec., '25	31 11/16	=52·1
,, '26	28 11/16	=47·1	,, Dec., '26	25	=41·1
,, '27	26 1/32	=42·8	,, Dec., '27	26½	=43·6
,, '28	26¾	=44·0	,, Dec., '28	26⅜	=43·3
,, '29	24 7/16	=40·2	,, Dec., '29	21 7/16	=35·2
,, '30	17 11/16	=29·0	,, Dec., '30	14 7/16	=23·7
,, '31	14⅖	=20·4	,, Dec., '31	20 7/16	=21·6
,, '32	17⅝	=19·5	,, Dec., '32	16½	=17·2
,, '33	18⅛	=18·7	,, Dec., '33	19 1/16	=19·5
,, '34	21 7/32	=20·0	,, Dec., '34	24⅝	=22·6
,, '35	29	=26·4	,, Dec., '35	22½	=20·6
,, '36	20 1/16	=18·5	,, Dec., '36	21 5/16	=19·4
,, '37	20 1/16	=18·4	,, Dec., '37	19 1/16	=17·7
,, '38	19 17/32	=17·6	,, Dec., '38	20 1/16	=17·3
,, '39	20 13/32	=17·1	,, Dec., '39	22½	=17·3
,, '40	22 19/64	=17·1	,, Dec., '40	23 5/16	=17·9
,, '41	23 7/16	=18·0	,, Dec., '41	23½	=18·1
,, '42	23½	=18·1	,, Dec., '42	23½	=18·1
,, '43	23½	=18·1	,, Dec., '43	23½	=18·1
,, '44	23½	=18·1	,, Dec., '44	23½	=18·1
,, '45	30½	=23·1	,, Dec., '45	44	=31·1
,, '46	48⅝	=36·7	,, Dec., '46	55½	=41·6

* All the index numbers in the table from 1916 to 1925 inclusive and from 1931 to date are calculated on the basis of the gold prices of silver instead of the sterling prices, though the latter are the price quotations given in the table. In arriving at the index numbers for these dates the prices of gold are taken as follows: For 1916, 1917 and 1918 the price is taken as 86*s.* 9½*d.* per fine oz., derived from the "pegged" New York rate of $4·76½ to the £. For 1919 the average price of gold is taken as 93*s.* 4¼*d.*, this being the parity price with the U.S. dollar, the average New York exchange in that year being $4·429. For the other dates the index numbers are based on the quotations in the London market for exportable gold. The quotation at the end of 1919 was 109*s.* 8¼*d.* per fine oz. The prices at the end of the years 1931–38 were 121*s.* 11*d.*, 123*s.* 9*d.*, 126*s.* 6*d.*, 141*s.* 0*d.*, 141*s.* 2*d.*, 141*s.* 7*d.*, 139*s.* 6*d.*, 149*s.* 7½*d.*, for the years 1939–44 168*s.* respectively, and 1945–46 172*s.* 3*d.*, and the average prices in these years were 92*s.* 6¼*d.*, 118*s.* 0¾*d.*, 124*s.* 10½*d.*, 137*s.* 7¾*d.*, 124*s.* 1¼*d.*, 140*s.* 3½*d.*, 140*s.* 8¾*d.*, 142*s.* 6½*d.*, 154*s.* 4*d.*, 168*s.*, 168*s.*, 168*s.*, 168*s.*, 170*s.* 4*d.* and 172*s.* 3*d.* respectively.

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World's Production of Silver (in millions of ounces)

	United States	Mexico	Canada	Australia	Other Countries	Total
1904	57·7	60·8	3·7	14·5	27·5	164·2
'05	56·1	65·0	5·9	15·0	30·3	172·3
'06	56·5	55·2	8·5	14·2	30·6	165·0
'07	56·5	61·0	12·8	19·0	34·8	184·2
'08	52·4	73·6	22·1	17·2	37·8	203·1
'09	54·7	73·9	27·5	16·3	39·7	212·1
'10	57·1	71·4	32·9	21·5	38·8	221·7
'11	60·4	79·0	32·7	16·6	37·5	226·2
'12	63·8	74·6	31·6	18·1	36·2	224·3
'13	66·8	70·7	31·5	3·5	51·4	223·9
'14	72·4	27·5	28·4	3·6	36·5	168·4
'15	74·9	39·5	28·4	4·1	37·3	184·2
'16	74·4	38·2	25·4	4·2	26·6	168·8
'17	71·7	35·0	22·2	10·0	35·3	174·2
'18	67·8	62·5	21·2	10·0	35·9	197·4
'19	56·7	62·7	15·7	7·4	32·0	174·5
'20	55·5	66·8	12·6	7·5	33·0	175·4
'21	53·1	64·5	13·1	4·9	35·7	171·3
'22	56·2	81·1	18·6	11·3	46·3	213·5
'23	73·3	90·9	17·8	13·3	50·7	246·0
'24	65·3	91·5	19·7	10·8	52·2	239·5
'25	66·1	92·9	20·2	11·1	54·8	245·1
'26	62·7	98·3	22·4	11·2	59·0	253·6
'27	60·4	104·6	22·7	9·0	57·3	254·0
'28	58·4	108·5	21·9	9·0	59·5	257·3
'29	61·2	108·7	23·1	9·0	59·7	261·7
'30	51·0	105·0	26·0	8·9	57·1	248·0
'31	31·0	86·0	21·0	7·6	50·4	196·0
'32	24·0	69·0	18·0	6·5	47·5	165·0
'33	22·8	68·1	15·2	11·0	52·0	169·1
'34	32·5	74·1	16·4	10·8	56·6	190·4
'35	45·6	75·6	16·6	11·4	71·5	220·7
'36	63·4	77·5	18·3	12·7	81·8	253·7
'37	71·3	84·7	22·7	14·3	80·9	274·5
'38	61·7	81·0	23·8		101·3	267·8
'39	63·9	75·9	24·5		101·6	265·9
'40	68·3	82·6	25·3		96·3	272·5
'41	71·1	78·4	23·4		90·1	263·0
'42	55·9	84·9	21·8		—	—
'43	44·8	71·2	18·5		—	—
'44	37·3	63·0	14·7		—	—
'45	29·3	61·0	14·0		—	—
46* ..	21·7	48·3	14·0		—	—

* Provisional. (Estimate by Messrs. Samuel Montagu & Co.)

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(000's omitted)

Year	Value of output £	Year	Value of output £	Year	Value of output £
1851	17,200	1883	20,640	1915	97,114
'52	26,550	'84	20,830	'16	92,597
'53	31,090	'85	21,250	'17	87,236
'54	25,490	'86	21,430	'18	78,605
'55	27,015	'87	21,735	'19	73,078
'56	29,520	'88	22,644	'20	68,522
'57	26,655	'89	25,375	'21	67,848
'58	24,930	'90	24,421	'22	66,723
'59	24,970	'91	26,846	'23	77,888
'60	23,850	'92	30,134	'24	81,807
'61	22,760	'93	32,363	'25	82,267
'62	21,550	'94	37,229	'26	82,211
'63	21,390	'95	40,843	'27	82,582
'64	22,600	'96	41,559	'28	82,400
'65	24,040	'97	48,509	'29	84,500
'66	24,220	'98	58,949	'30	88,500
'67	22,805	'99	63,027	'31	95,100
'68	21,945	1900	52,312	'32	103,400
'69	21,245	'01	53,630	'33	107,700
'70	21,370	'02	60,975	'34	116,000
'71	25,400	'03	67,337	'35	125,700
'72	24,200	'04	71,380	'36	140,900
'73	23,600	'05	78,143	'37	148,700
'74	22,950	'06	82,707	'38	159,000
'75	22,700	'07	84,857	'39	165,900
'76	22,540	'08	90,995	'40	174,000*
'77	23,830	'09	93,302	'41	159,400*
'78	22,020	'10	93,544	'42	146,300*
'79	21,400	'11	94,930	'43	112,600*
'80	22,130	'12	95,783	'44	100,900*
'81	21,150	'13	97,481	'45	97,900*
'82	20,500	'14	92,709	'46	100,500*

Gold.—The table shows the world's annual gold production since 1851. Prior to 1911 the estimates are those of the Bureau of the U.S. Mint and other authorities. The estimates since 1926 are those of the Union Corporation, Limited. The value is taken throughout at £4·25 per fine oz.

* Estimated or provisional figure.

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*Average Prices of Commodities**

No. of Article	0	1	2	3	4	5	6	7	8	1–8	9	10
		Wheat		Flour	Barley	Oats	Maize §	Potatoes*	Rice	Vegetable Food	Beef ‡	
Year	Silver †	English *Gazette*	American	Town Made white (now "G.R.")	English *Gazette*	English *Gazette*	American Mixed	Good English	Rangoon Cargoes to Arrive	Total	•Prime	Middling
	d. per oz.	*s.* and *d.* per qr.	*s.* and *d.* per qr.	*s.* per sack (280 lbs.)	*s.* and *d.* per qr.	*s.* and *d.* per qr.	*s.* per qr.	*s.* per ton	*s.* and *d.* per cwt.		*d.* per 8 lbs.	*d.* per 8 lbs.
1922 ..	34 7/16	47·10	52·11	45 3/4	40·1	29·1	31 1/4	130	14·10	—	88 5/8	82
'25 ..	32 1/8	52·2	62·4	50 1/8	42·0	27·2	38 9/16	154	16·0	—	80	73 1/2
'26 ..	28 11/16	53·3	58·9	49 1/4	36·11	25·1	29 13/16	127	16·3	—	74	67
'27 ..	26 3/32	49·3	58·3	44 9/16	42·0	25·4	30 9/16	136	15·11	—	70	62
'28 ..	26 1/4	44·8	50·10	40 1/16	39·0	29·0	38 15/32	133	15·0	—	74	66 1/2
'29 ..	24 7/16	42·2	51·3	38 1/2	35·5	24·7	36 1/4	111	14·3	—	71	66
'30 ..	17 11/16	34·3	36·10	33 1/2	28·3	17·2	23	93	13·0	—	73	68
'31 ..	14 5/8	24·0	25·1	22 7/8	28·0	17·8	15 9/16	146	9·8	—	67	61
'32 ..	17 27/32	25·0	27·5	24 7/32	27·1	19·3	18 13/16	152	9·8	—	65	59
'33 ..	18 1/8	22·10	25·7	23 9/32	28·7	15·10	17 7/16	86	7·9	—	61	52
'34 ..	21 7/32	20·2	28·0	23 1/8	30·11	17·5	19 19/32	97	7·8	—	58	52
'35 ..	29	22·2	31·1	25 3/4	28·7	18·9	17 1/4	107	8·10	—	54	49
'36 ..	20 1/16	30·9	35·1	31 17/32	29·5	17·8	19 1/2	146	9·0	—	54	50
'37 ..	20 1/16	40·0	49·7	40 1/2	39·0	23·11	26 9/16	136	10·5	—	61	57
'38 ..	19 17/32	28·11	39·3	30 21/32	36·4	21·2	28 7/16	111	10·7	—	62	58
'39 ..	20 13/32	21·5	30·1	22 9/32	31·7	19·3	26 1/2	117	11·1	—	61	58
'40 ..	22 19/64	42·10	33·6	24 5/16	64·10	37·2	39 13/16	143	15·5	—	72	68
'41 ..	23 7/16	62·10	32·2	27 1/2	85·8	40·10	43 ‖	164	23·8	—	72	68
'42 ..	23 1/2	68·6	36·9	35	165·5	42·0	43 ‖	134	26·0	—	76	68
'43 ..	23 1/2	69·8	45·5	38 1/4	112·5	43·8	43 ‖	111	27·2	—	79	71
'44 ..	23 1/2	63·11	56·0	38 3/4	94·6	45·3	43 ‖	115	27·2	—	79	71
'45 ..	30 1/2	61·10	63·7	40	89·2	45·9	43 ‖	139	27·2	—	79	71
'46 ..	48 5/8	63·7	65·11	40	86·6	45·3	43 ‖	137	27·2	—	79 1/4	72
Average												
1904–13	26 3/4	31 1/2	36	30	25 1/2	18 1/2	24 1/2	78	7 1/2	—	51	44 1/2
1890–99	34	28 1/2	31 1/2	27 1/2	25 1/2	17 1/2	19 1/2	72	6 1/4	—	47	37 1/2
'78–87	50	40	43 1/2	34 1/2	31 1/2	21	25	102	8	—	55 1/2	46
'67–77	58 1/2	54 1/2	56	46	39	26	32 1/2	117	10	—	59	50
	Index Numbers (or Percentages) of Prices, the Average of 1867–77 being 100											
1922 ..	51·6	88	95	100	103	112	96	111	148	853	150	164
'25 ..	52·5	96	111	109	108	105	119	132	160	940	136	147
'26 ..	47·1	98	105	107	95	96	92	109	163	865	125	134
'27 ..	42·8	90	104	98	108	97	95	116	159	867	119	124
'28 ..	44·0	82	91	87	100	112	118	114	150	854	125	133
'29 ..	40·2	77	91	84	91	95	112	95	143	788	120	132
'30 ..	29·0	63	66	72	72	66	71	79	130	619	124	136
'31 ..	20·4	44	45	50	71	68	48	125	93	544	114	122
'32 ..	19·5	46	49	53	69	74	58	130	93	572	110	118
'33 ..	18·7	42	46	52	73	61	53	74	78	479	103	104
'34 ..	20·0	37	50	50	79	67	60	83	77	503	98	104
'35 ..	26·4	41	56	56	73	72	53	91	88	530	92	98
'36 ..	18·5	56	63	69	75	68	60	125	90	606	92	100
'37 ..	18·4	73	89	88	100	92	82	116	105	745	103	114
'38 ..	17·6	53	70	67	93	81	86	95	106	651	105	116
'39 ..	17·1	39	54	48	81	74	82	100	111	589	103	116
'40 ..	17·1	78	60	53	166	143	122	122	154	898	122	136
'41 ..	18·0	115	57	60	220	157	132	140	236	1,117	122	136
'42 ..	18·1	126	66	76	424	162	132	115	260	1,361	129	136
'43 ..	18·1	128	81	83	288	168	132	95	272	1,247	134	142
'44 ..	18·1	117	100	84	242	174	132	98	272	1,219	134	142
'45 ..	23·1	113	114	87	229	176	132	118	272	1,241	134	142
'46 ..	36·7	117	118	87	222	174	132	117	272	1,239	135	144

* The annual prices are the average monthly or weekly quotations, except potatoes, which are the average weekly quotations during the eight months January to April and September to December.

† Not included in the general average. ‡ Meat (9–13), by the carcase, in the London Central Meat Market.

§ La Plata from 1924. ‖ Argentine maize (Feeding Stuffs); £10 per ton fixed by Ministry of Food.

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Average Prices of Commodities—Contd.

No. of Article	11	12	13	14	15	9–15	16A	16B	17	18A *	18B *	18
	Mutton		Pork	Bacon	Butter		Sugar			Coffee		
Year	Prime	Middling	Large and Small, average	Waterford	Friesland, Fine to Finest	Animal Food Total	British West Indian Refining‖	Beet, German, 88 p. c., f.o.b.	Java, Floating Cargoes §	Ceylon Plantation, Low Middling†	Rio, Good	Mean of 18A and 18B
	d. per 8 lbs.	*d.* per 8 lbs.	*d.* per 8 lbs.	*s.* per cwt.	*s.* per cwt.		*s.* per cwt.	*s.* per cwt.	*s.* per cwt.	*s.* per cwt.	*s.* per cwt.	
1922 ..	125	121 2/8	101	145 1/8	202 1/2	—	15	14 1/8	15 5/16	120 3/4	74 1/4	—
'25 ..	106 3/8	98 5/8	84 1/2	128 1/2	206 7/8	—	16 1/4	11 5/8	12 1/3	153 13/16	98 5/16	—
'26 ..	89	80 1/2	98 5/8	130	173	—	16 7/32	11 3/4	12 5/8	154 3/4	89 1/16	—
'27 ..	86	79 3/5	85	102 1/4	178	—	16 7/16	12 1/2	13 9/16	143 1/2	71 1/2	—
'28 ..	92 1/4	87	77	101 3/4	185 7/8	—	13 1/2	10 11/16	11 1/2	143 9/32	81 11/32	—
'29 ..	89 1/2	83	91	116 13/32	180 1/8	—	11 7/32	8 5/8	8 7/8	141 1/8	74 27/32	—
'30 ..	92	86	89	105 5/8	146 13/16	—	8 5/8	5 27/32	6 13/32	106 23/32	42 11/32	—
'31 ..	79	73	65	83 3/8	130	—	7 13/16	5 11/16	6 7/16	101 1/4	33 15/16	—
'32 ..	63	55	54	77	126 3/8	—	7 1/2	5 5/16	5 19/32	105 3/32	54 5/16	—
'33 ..	69	63	60	81 1/2	105 9/16	—	7 5/32	4 23/32	5 1/4	86 25/32	42 1/8	—
'34 ..	74	70	65	90 9/32	79 5/8	—	6 5/32	4 5/32	4 1/16	87 7/32	42 13/16	—
'35 ..	75	70	62	89	92 5/8	—	6 1/16	3 21/32	4 3/4	67 9/16	29 21/32	—
'36 ..	73	68	65	93 27/32	98 21/32	—	6 13/32	3 1/32	4 3/4	58 1/2	30 23/32	—
'37 ..	78	74	68	94	108 1/32	—	7 11/32	5 1/4	6 1/2	75 3/4	36 3/4	—
'38 ..	62	56	69	97 3/16	114 9/16	—	7 1/32	4 5/16	5 15/32	75	19 3/4	—
'39 ..	68	64	70	97 3/4	122	—	9 3/32	6 1/32	7 7/32	73 3/4	22 1/2	—
'40 ..	85	76	96	114 7/8	143	—	9 3/4	—	8 1/8	86 5/16	28 3/32	—
'41 ..	85	76	96	123 11/16	142 11/16	—	9 3/4	—	8 1/8	137 1/2	30 1/4	—
'42 ..	90	78	101	130	143 1/2	—	9 3/4 ‡	—	8 1/8 ‡	130 ‡	28 3/4 ‡	—
'43 ..	96	84	102	142	151 1/3	—	9 3/4 ‡	—	8 1/8 ‡	140 ‡	37 ‡	—
'44 ..	96	84	102	142	151 1/3	—	9 3/4 ‡	—	8 1/8 ‡	140 ‡	37 ‡	—
'45 ..	96	84	102	142	151 1/3	—	9 3/4 ‡	—	8 1/8 ‡	140 ‡	59 ‡	—
'46 ..	100 3/4	81 1/2	97	142	139 3/4	—	—	—	23 1/4	150 ‡	77 1/4	—
Average 1904–13	58 1/4	51 3/4	47 5/8	67	113	—	10 1/2	10 7/8	12	75 1/2	43 3/4	—
1890–99	54 1/2	41 1/2	42 3/4	59	100	—	11 1/2	11 1/2	13 3/4	98	62	—
'78–87	64 1/2	53	49	71	116	—	17	18	21 1/2	78	52	—
'67–77	63	55	52	74	125	—	23	24	28 1/2	87	64	—
Index Numbers (or Percentages) of Prices, the Average of 1867–77 being 100												
1922 ..	199	221	194	196	162	1,286	62		54	* 140	* 116	128
'25 ..	169	180	162	174	165	1,133	60		43	176	154	165
'26 ..	141	146	190	176	138	1,050	60		44	178	139	159
'27 ..	136	145	163	138	142	967	62		47	165	112	139
'28 ..	146	158	148	137	149	996	51		40	165	127	146
'29 ..	142	151	175	157	144	1,021	42		31	162	117	140
'30 ..	146	155	171	143	117	992	31		22	123	66	95
'31 ..	125	133	125	113	104	836	29		23	120	53	87
'32 ..	100	100	104	104	101	737	27		20	121	85	103
'33 ..	110	114	115	110	84	740	25		18	100	66	83
'34 ..	117	127	125	122	64	757	22		16	100	67	84
'35 ..	119	127	119	120	74	749	21		17	78	46	62
'36 ..	116	124	131	127	79	763	21		17	67	48	58
'37 ..	124	135	125	127	86	820	28		23	87	57	72
'38 ..	98	102	133	131	92	777	24		19	86	31	59
'39 ..	108	116	135	132	98	808	32		26	85	35	60
'40 ..	135	138	185	155	114	985	42		29	99	44	72
'41 ..	135	138	185	167	114	997	42		29	158	47	102
'42 ..	143	142	194	176	115	1,035	42		29	150	45	98
'43 ..	152	153	196	192	121	1,090	42		29	161	58	109
'44 ..	152	153	196	192	121	1,090	42		29	161	58	109
'45 ..	152	153	196	192	121	1,090	42		29	161	93	127
'46 ..	160	148	187	192	112	1,078	—		82	172	121	146

* Index numbers not included in general average. ‡ Nominal.
† E. India good middling from 1908. § Raw Centrifugals, 96% Pol., from 1924.
‖ White Javas, C.C.F., from 1934.

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Average Prices of Commodities—Contd.

No. of Article	19A *	19B *	19	16–19	1–19	20A	20B	21	22	23	24	25
	Tea			Sugar, Coffee, and Tea	Food	Iron			Copper	Tin	Lead	Coal
Year	Congou, Common *d.* per lb.	Average Import Price *d.* per lb.	Mean of 19A and 19B	Total	Total	Scottish Pig *s.* and *d.* per ton	Cleveland (Middlesbrough) Pig *s.* and *d.* per ton	Bars, Common per ton	Standard £ per ton	Straits £ per ton	English Pig £ per ton	Wallsend Hetton in London § *s.* per ton
1922 ..	8 5/8	14·9	—	—	—	99·10	90·7	11 1/2	63 1/4	162	25 3/4	34 2/3
'25 ..	7 7/8	18·34	—	—	—	83·4	72·8	11 7/8	61 13/16	267	37 7/16	29 5/8
'26 ..	7 13/16	18·82	—	—	—	87·2	87·6	11 1/2	58 1/32	297 9/16	32 1/8	†30 7/24
'27 ..	6 3/4	18·58	—	—	—	80·5	73·0	11 1/4	55 3/4	303 7/8	25 9/16	23 1/16
'28 ..	6 5/16	16·84	—	—	—	69·9	65·9	9 15/16	63 3/4	229 7/16	22 5/16	21 7/16
'29 ..	6 1/16	16·11	—	—	—	74·0	70·3	9 3/4	75 9/16	207 7/16	24 1/32	23 1/8
'30 ..	5 7/32	15·12	—	—	—	76·0	67·0	9 31/32	54 3/4	144 29/32	19 1/2	24 7/32
'31 ..	4 13/16	13·29	—	—	—	71·0	58·6	10 3/32	38 1/8	121 1/8	14 9/32	24 5/8
'32 ..	4 9/32	10·75	—	—	—	68·2	58·6	10	31 31/32	140	13 5/16	23 11/32
'33 ..	6 21/32	11·87	—	—	—	66	62·3	9 11/16	32 31/32	202 1/2	13 1/4	22 3/8
'34 ..	8 21/32	13·20	—	—	—	69·6	66·11	9 17/32	30 9/32	232 1/4	12 13/32	20 1/4
'35 ..	6 23/32	13·06	—	—	—	70·6	67·10	9 5/8	32 1/2	230 15/32	16	20 3/8
'36 ..	6 1/4	13·19	—	—	—	78·6	73·2	10 3/16	37 13/32	207 21/32	19 15/32	23 3/32
'37 ..	6 9/16	14·58	—	—	—	104·6	94·4	12 5/16	54 21/32	246 3/4	24 29/32	24 1/2
'38 ..	6 15/32	14·04	—	—	—	118·0	109	13 1/4	41 21/32	193 31/32	17 1/16	25 11/16
'39 ..	6 1/4 ‖	14·18	—	—	—	104·3	100·7	12 3/8	44 1/4	232 15/32	17 3/8	25 11/32
'40 ..	—	15·33	—	—	—	114·10	116·4	14 5/16	62	273 5/16	26 1/2	28 1/16
'41 ..	—	15·13	—	—	—	123	128	15 5/8	62	284 5/16	26 1/2	30 27/32
'42 ..	—	16·25	—	—	—	123	128	15 5/8	62	275	26 1/2	32 1/2
'43 ..	—	18·44	—	—	—	123	128	15 5/8	62	275	26 1/2	34 15/16
'44 ..	—	19·48	—	—	—	123	128	16 1/2	62	300	26 1/2	38 5/8
'45 ..	—	20·06	—	—	—	139 15/16	140 1/2	18	62	300	29 1/8	42 2/3
'46 ..	—	21·31	—	—	—	167	165 1/2	19 5/8	77 1/8	321 5/8	47 1/4	45 1/6
Average 1904–13	7 7/8	8 1/8	—	—	—	57 3/4	51 1/2	6 7/8	67 3/4	164 7/8	15 5/8	18 1/8
1890–99	4 5/8	9 3/4	—	—	—	47	41 1/2	5 1/2	50	81	12	17 1/2
'78–87	6 3/4	12 3/4	—	—	—	46	38	5 1/2	55	89	14	16 3/4
'67–77	11 1/4	17 1/4	—	—	—	69	60	8 1/4	75	105	20 1/2	22
	Index Numbers (or Percentages) of Prices, the Average of 1867–77 being 100											
1922 ..	* 77	* 86	82	326	2,465	148	136	84	154	123	156	
'25 ..	70	106	88	356	2,429	121	144	82	254	183	135	
'26 ..	69	109	89	352	2,267	135	139	77	283	157	138	
'27 ..	60	108	84	332	2,166	119	136	74	289	125	105	
'28 ..	56	98	77	314	2,164	105	120	85	239	109	97	
'29 ..	54	93	74	287	2,096	112	118	101	198	117	106	
'30 ..	46	88	67	215	1,826	111	121	73	138	95	113	
'31 ..	42	78	60	199	1,579	100	123	52	115	71	112	
'32 ..	38	62	50	200	1,509	98	121	43	131	65	106	
'33 ..	58	68	63	189	1,408	99	117	44	193	65	103	
'34 ..	77	77	77	199	1,459	106	116	40	221	61	92	
'35 ..	60	76	68	168	1,447	107	117	43	219	78	92	
'36 ..	56	76	66	162	1,531	118	123	50	198	95	105	
'37 ..	58	85	72	195	1,760	154	149	73	235	121	111	
'38 ..	58	81	70	172	1,600	176	161	56	185	83	117	
'39 ..	56	82	69	187	1,584	159	150	59	221	85	115	
'40 ..	—	89	89	232	2,115	179	173	83	260	129	127	
'41 ..	—	88	88	261	2,375	195	189	83	271	129	141	
'42 ..	—	94	94	263	2,659	195	189	83	262	129	148	
'43 ..	—	107	107	287	2,624	195	189	83	262	129	159	
'44 ..	—	113	113	293	2,602	195	200	83	286	129	176	
'45 ..	—	116	116	314	2,645	217	218	83	286	142	194	
'46 ..	—	124	124	352	2,669	258	238	103	306	233	205	

* Index numbers not included in the general average.
§ Best Yorkshire house after 1916.
† Average price January–April, 1926.
‖ First 9 months only.

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Average Prices of Commodities—Contd.

No. of Article	26	20–26	27	28	29A	29B	30A	30B	31	32A	32B	33
	Coal	Minerals	Cotton		Flax		Hemp		Jute	Wool		
Year	Average Export Price *s.* per ton	Total	Middling American *d.* per lb.	Fair Dhollerah ‖ *d.* per lb.	Petrograd ¶ £ per ton	Russian Average Import Price £ per ton	Manila Fair Roping £ per ton	Petrograd Clean (*a*) £ per ton	Good Medium†† £ per ton	Merino, Port Phllip, Average Fleece *d.** perl b.	Merino, Adelaide, Average Greasy *d.* per lb.	English Lincoln Half Hogs *d.* per lb.
1922 ..	24·16	—	12·10	8	95	84 7/8	33 1/2	57 ‡	30 3/4	39	17 1/8	9 3/4
'25 ..	20·08	—	12·64	11·01	92 1/2	120 3/4	46 1/8	89 1/4	49 1/16	41 1/16	17 1/8	17 1/16
'26 ..	18·59	—	9·40	7·75	65	72 15/16	43	74 5/8	43 7/8	36 1/2	16 7/16	15
'27 ..	17·80	—	9·54	8·27	95 13/16	74 1/2	43 3/8	66 5/16	32 3/4	38 1/16	17 7/16	15 13/32
'28 ..	15·67	—	10·92	8·66	98 1/2	91 15/16	37 1/16	63 13/32	33 13/16	37	17 5/16	17 29/32
'29 ..	16·13	—	10·26	7·73	76 7/16	71 7/32	37 3/32	61	32	35 3/8	13 3/32	16 1/16
'30 ..	16·64	—	7·49	5·12	53 1/8	60 7/32	26 1/2	48 7/32	20	18 9/32	8 13/32	10 3/4
'31 ..	15·98	—	5·90	4·60	36	35 9/16	18 3/4	27 1/2	15 15/16	14·7	7·1	8 1/4
'32 ..	16·27	—	5·24	4·85	45 7/32	42 5/32	18 23/32	36	16 3/32	15·0	7·2	5 25/32
'33 ..	16·08	—	5·54	4·53	51 13/32	48 15/32	15 7/8	37	14 3/8	19·9	9·3	5 23/32
'34 ..	16·08	—	6·70	4·80	60 1/16	50 29/32	14 29/32	42 5/16	14 3/32	21 1/4	10·4	7
'35 ..	16·30	—	6·71	5·42	79 3/8	72 5/16	19 1/32	43 1/4	16 15/16	20·1	9·5	7 1/32
'36 ..	16·98	—	6·71	5·12	63 25/32	60 15/16	28 1/32	42 27/32	17 1/32	24·7	12·2	10 5/16
'37 ..	19·05	—	6·21	4·80	78 13/32	70 3/32	34 5/16	38 3/8	19 1/16	26·9	12·7	16·9
'38 ..	21·32	—	4·93	3·67	66 29/32	63 1/2	21 25/32	38 5/16	17 21/32	18·6	8·9	11·9
'39 ..	21·12	—	5·95	4·41	90 21/32	72 9/16	22 5/16	48 5/16	26 19/32	17·9	9·0	12·2
'40 ..	27·23	—	8·10	6·26	177 1/32	183 1/32	26 3/8	100 1/32	27 3/4	29·6	14·9	19·4
'41 ..	32·22	—	9·14	7·65	200 ‡	—	31 1/32	126 ‡	26 13/32	32	16 1/8	21
'42 ..	34·87	—	8·83	7·37	200 ‡	201·6	33 ‡	130 ‡	24 3/4	32	16 1/8	21
'43 ..	36·91	—	7·83	6·38	200 ‡	205 ‡	33 ‡	130 ‡	33 1/8	32	16 1/8	21
'44 ..	39·19	—	11·32	9·50	200 ‡	205 ‡	40 1/2 ‡	130 ‡	40 1/4	32	16 1/8	21
'45 ..	40·27	—	12·75	10·80	200 ‡	230 (*b*)	40 1/2 ‡	130 ‡	39 1/4	31·6	15·9	21·1
'46 ..	40·94	—	14·87	12·14	252	244 3/8	51	144 1/2	49 1/6	35 3/16	16 3/4	20·7
Average 1904–13	11 7/8	—	6 1/2	5	32 1/2	36 7/8	30 3/8	31 3/8	18 7/8	17 3/8	9	10 7/8
1890–99	10 3/8	—	4 1/4	3	27	27	26 1/2	25	12 1/2	13 1/2	6 1/2	10
'78–87	9	—	6	4 1/4	33	34	35 1/2	26 1/2	15	18 1/2	8 3/8	11 1/4
'67–77	12 1/2	—	9	6 3/4	46	48	43	35	19	21 1/4	9 7/8	19 3/4
	Index Numbers (or Percentages) of Prices, the Average of 1867–77 being 100											
1922 ..	193	994	134	118	191		116		162	180		49
'25 ..	161	1,080	140	163	227		174		261	188		87
'26 ..	149	1,078	104	115	147		151		231	170		76
'27 ..	142	990	106	123	181		141		172	177		78
'28 ..	125	860	121	128	203		130		178	174		91
'29 ..	129	881	114	114	157		126		168	156		81
'30 ..	133	784	83	76	121		96		105	86		54
'31 ..	127	700	66	68	76		58		84	70		43
'32 ..	130	694	58	72	93		70		85	71		29
'33 ..	129	750	62	67	106		68		78	94		30
'34 ..	129	765	74	71	119		73		74	102		35
'35 ..	130	786	74	80	161		80		89	96		37
'36 ..	136	825	74	76	133		91		93	119		53
'37 ..	152	995	69	71	158		93		104	127		86
'38 ..	171	949	55	54	139		77		93	88		60
'39 ..	169	958	66	65	174		91		140	86		62
'40 ..	218	1,169	90	93	383		163		146	142		98
'41 ..	258	1,266	101	113	416		202		139	155		106
'42 ..	279	1,285	98	109	427		209		130	155		106
'43 ..	295	1,312	87	95	431		209		174	155		106
'44 ..	314	1,383	126	141	431		219		212	155		107
'45 ..	322	1,462	142	160	457		219		207	153		105
'46 ..	328	1,671	165	180	528		251		259	167		

* Port Philip fleece washed nominal since 1895, exactly in proportion with the value of clean wool.
‡ Nominal. ‖ Now No. 1 Oomra, Fine.
¶ Livonian Z.K. from 1921–45. Medium grade continental w/retted in 1946.
†† Lightnings from 1931 to 1942. Daisee ⅔ from 1943.
(*a*) Russian Siretz Croup 1, Sort 1 from 1931–33; Jugo-Slav Peasant from 1934–45. Italian S.B. in 1946.
(*b*) Average of 4 months only. Belgian in 1946.

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Average Prices of Commodities—Contd.

No. of Article	34	27–34	35A	35B	35C	36A	36B	37	38	39	40A	40B
	Silk	Textiles	Hides			Leather		Tallow	Oil			Seeds
Year	Tastlee *	Total	River Plate, Dry	River Plate, Salted	Average Import Price	Dressing Hides	Average Import Price	Town	Palm	Olive	Linseed	Linseed
	s. per lb.		*d.* per lb.	*d.* per lb.	*d.* per lb.	*d.* per lb.	*d.* per lb.	*s.* per cwt.	£ per ton	£ per ton	£ per ton	*s.* per qr.
1922 ..	$28\frac{3}{4}$	—	$9\frac{1}{8}$	$8\frac{7}{8}$	8·06	$24\frac{1}{3}$	36	$34\frac{5}{8}$	$34\frac{3}{4}$	$75\frac{1}{2}$ †	$39\frac{1}{8}$	$75\frac{1}{2}$
'25 ..	$18\frac{1}{8}$	—	$11\frac{7}{16}$	$8\frac{13}{16}$	9·87	23	33	$42\frac{1}{4}$	$40\frac{5}{8}$	$73\frac{3}{4}$	$43\frac{1}{4}$	$80\frac{7}{16}$
'26 ..	$15\frac{15}{16}$	—	$10\frac{5}{16}$	8	9·32	$21\frac{1}{5}$	$35\frac{11}{16}$	$38\frac{1}{6}$	$37\frac{5}{8}$	$79\frac{9}{16}$	$32\frac{1}{8}$	$63\frac{7}{16}$
'27 ..	$15\frac{7}{16}$	—	$12\frac{5}{16}$	$10\frac{7}{16}$	9·85	$22\frac{15}{16}$	$36\frac{13}{16}$	$33\frac{7}{8}$	$34\frac{1}{4}$	$102\frac{5}{8}$	$31\frac{3}{4}$	$64\frac{5}{16}$
'28 ..	14	—	$15\frac{7}{16}$	$11\frac{29}{32}$	12·09	$23\frac{13}{16}$	$37\frac{7}{16}$	$36\frac{15}{16}$	$35\frac{3}{4}$	$80\frac{7}{16}$	$29\frac{7}{8}$	$66\frac{15}{16}$
'29 ..	$13\frac{7}{8}$	—	$10\frac{9}{16}$	$8\frac{1}{4}$	10·80	$19\frac{1}{4}$	$38\frac{1}{4}$	$36\frac{13}{32}$	$34\frac{21}{32}$	72	$35\frac{15}{32}$	$74\frac{1}{8}$
'30 ..	$10\frac{15}{16}$	—	$6\frac{25}{32}$	$6\frac{1}{2}$	7·80	$18\frac{1}{2}$	$33\frac{1}{2}$	$28\frac{23}{32}$	$25\frac{1}{4}$	$52\frac{1}{8}$	$36\frac{5}{8}$	$61\frac{15}{16}$
'31 ..	$8\frac{15}{16}$	—	$5\frac{1}{2}$	$5\frac{9}{16}$	6·12	$17\frac{3}{4}$	$32\frac{1}{4}$	$19\frac{1}{3}$	$19\frac{7}{16}$	$53\frac{9}{16}$	$18\frac{3}{16}$	$38\frac{7}{8}$
'32 ..	$8\frac{5}{32}$	—	$4\frac{9}{16}$	$4\frac{3}{4}$	5·47	$17\frac{3}{32}$	$28\frac{7}{8}$	$21\frac{1}{16}$	$17\frac{5}{8}$	$57\frac{3}{16}$	17	$38\frac{5}{16}$
'33 ..	$6\frac{3}{4}$	—	$5\frac{1}{4}$	$4\frac{11}{16}$	5·65	$17\frac{11}{32}$	$26\frac{29}{32}$	$19\frac{27}{32}$	$15\frac{11}{16}$	$53\frac{15}{16}$	$20\frac{3}{4}$	$39\frac{1}{4}$
'34 ..	$5\frac{7}{16}$	—	$4\frac{13}{16}$	$4\frac{7}{8}$	5·71	$17\frac{1}{2}$	$25\frac{5}{16}$	$17\frac{1}{4}$	$13\frac{17}{32}$	$62\frac{3}{16}$	$21\frac{13}{32}$	$42\frac{3}{8}$
'35 ..	$5\frac{13}{32}$	—	$5\frac{5}{32}$	$5\frac{1}{8}$	5·51	$17\frac{1}{2}$	$25\frac{13}{16}$	$24\frac{5}{8}$	$19\frac{3}{8}$	$61\frac{13}{32}$	$24\frac{13}{32}$	$43\frac{1}{4}$
'36 ..	$5\frac{25}{32}$	—	$6\frac{1}{4}$	6	6·47	$17\frac{1}{2}$	$27\frac{11}{32}$	$23\frac{9}{32}$	$19\frac{31}{32}$	$70\frac{3}{16}$	$28\frac{1}{4}$	$48\frac{5}{32}$
'37 ..	$8\frac{7}{16}$	—	$8\frac{21}{32}$	$7\frac{9}{16}$	8·62	$18\frac{9}{32}$	$28\frac{5}{16}$	$23\frac{15}{32}$	$22\frac{9}{16}$	$95\frac{23}{32}$	$31\frac{1}{8}$	$54\frac{11}{32}$
'38 ..	$7\frac{31}{32}$	—	$6\frac{21}{32}$	$5\frac{9}{16}$	6·35	$14\frac{5}{16}$	$24\frac{1}{32}$	$17\frac{13}{32}$	$14\frac{7}{8}$	$68\frac{19}{32}$	$26\frac{7}{16}$	$46\frac{27}{32}$
'39 ..	$13\frac{3}{32}$	—	$6\frac{3}{4}$	$6\frac{1}{8}$	6·39	$18\frac{5}{32}$	$23\frac{1}{16}$	$16\frac{9}{32}$	$14\frac{5}{16}$	$73\frac{13}{16}$	$29\frac{1}{8}$	$49\frac{25}{32}$
'40 ..	$17\frac{1}{2}$	—	8	$8\frac{1}{2}$	8·50	$25\frac{7}{32}$	$23\frac{3}{4}$	$22\frac{3}{32}$	19	$114\frac{1}{4}$	$44\frac{3}{32}$	$66\frac{1}{8}$
'41 ..	$15\frac{21}{32}$	—	$7\frac{1}{2}$	$8\frac{1}{2}$	8·45	$24\frac{3}{8}$	$24\frac{1}{4}$	$22\frac{1}{2}$	$20\frac{3}{4}$	118	$41\frac{1}{2}$	$70\frac{1}{4}$
'42 ..	16 †	—	$8\frac{1}{8}$	9	9·25	26	$26\frac{1}{8}$	$24\frac{3}{16}$	23	118	$44\frac{13}{16}$	$78\frac{9}{16}$
'43 ..	16 †	—	$8\frac{7}{8}$	$9\frac{1}{16}$	9·49	27	$24\frac{15}{16}$	$34\frac{1}{8}$	36	118 †	$48\frac{1}{2}$	$109\frac{1}{2}$
'44 ..	16 †	—	$10\frac{1}{16}$	$9\frac{3}{8}$	10·14	27	$28\frac{7}{8}$	$43\frac{1}{2}$	$42\frac{1}{4}$	118 †	$60\frac{3}{4}$	$107\frac{3}{4}$
'45 ..	16 †	—	$10\frac{1}{16}$	$9\frac{3}{8}$	9·42	25	$31\frac{1}{8}$	$43\frac{1}{2}$	$42\frac{1}{4}$	150 †	62	$109\frac{1}{2}$
'46 ..	$44\frac{1}{2}$	—	$17\frac{7}{8}$	$15\frac{5}{8}$	11·73	29	$38\frac{1}{5}$	$46\frac{1}{4}$	$43\frac{3}{8}$	270	$87\frac{7}{8}$	$130\frac{3}{4}$
Average												
1904–13	$11\frac{3}{4}$	—	$9\frac{5}{8}$	$7\frac{1}{2}$	$6\frac{7}{8}$	16	17	$31\frac{1}{2}$	$31\frac{1}{4}$	$43\frac{3}{4}$	$26\frac{5}{8}$	$49\frac{1}{2}$
1890–99	$11\frac{1}{2}$	—	$6\frac{1}{4}$	$5\frac{1}{2}$	5	$13\frac{1}{4}$	$13\frac{3}{4}$	25	$24\frac{1}{2}$	35	$19\frac{1}{4}$	38
'78–87	15	—	$8\frac{5}{8}$	$6\frac{3}{4}$	$6\frac{1}{2}$	15	17	$35\frac{1}{2}$	$32\frac{1}{2}$	40	23	46
'67–77	23	—	9	7	$6\frac{7}{8}$	16	$18\frac{3}{4}$	45	39	50	30	60

Index Numbers (or Percentages) of Prices, the Average of 1867–77 being 100

1922 ..	125	1,075	114	174	77	89	151	127
'25 ..	79	1,319	132	161	85	104	147	137
'26 ..	69	1,063	121	164	75	96	159	106
'27 ..	67	1,045	142	172	82	88	205	107
'28 ..	61	1,086	172	176	81	92	161	108
'29 ..	60	976	129	166	64	89	144	122
'30 ..	48	669	92	150	43	65	104	110
'31 ..	39	504	77	146	47	51	108	63
'32 ..	35	513	66	132	44	45	114	61
'33 ..	29	534	68	127	39	40	108	67
'34 ..	24	572	67	123	55	35	124	71
'35 ..	24	641	69	125	52	50	123	75
'36 ..	25	646	82	129	52	51	140	85
'37 ..	37	745	109	134	39	58	192	95
'38 ..	35	601	81	110	36	38	137	81
'39 ..	57	741	84	119	49	37	148	88
'40 ..	76	1,191	109	141	50	49	228	122
'41 ..	68	1,300	107	135	54	53	236	124
'42 ..	70	1,304	116	150	76	59	236	137
'43 ..	70	1,327	120	149	81	92	236	176
'44 ..	70	1,460	132	161	97	108	236	187
'45 ..	70	1,515	129	161	97	108	300	190
'46 ..	193	1,848	199	194	103	111	540	243

* Common New Style from 1921 to 1936. China, Extra "A" from 1937. † Nominal.

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Average Prices of Commodities—Contd.

No. of Article	41A ‡	41B ‡	41C ‡	41	42	43	44	45A	45B	35–45	20–45	1–45
	Petroleum *				Soda		Indigo	Timber				
Year	Motor Spirit c.i.f. *d.* per imp. gall.	Kerosene (Burning Oil) c.i.f. *d.* per imp. gall.	Gas Oil c.i.f. *d.* per imp. gall.	Mean of 41A, 41B and 41C	Crystals *s.* per ton	Nitrate of Soda *s.* per cwt.	Bengal, Good Consuming *s.* per lb.	Hewn, Average Import Price *s.* per load	Sawn or Split, Average Import Price *s.* per load	Sundry Materials Total	Materials Total	Grand Total
1922 ..	15·89	6·32	3·98	—	123	14 1/2	9 5/8	46 5/8	117 1/2	—	—	—
'25 ..	9·98	4·96	4·22	—	100	13 3/8	5 3/4	47 15/16	122 15/16	—	—	—
'26 ..	9·21	5·66	4·25	—	100	13 1/4	5 5/8	48 29/32	107	—	—	—
'27 ..	7·25	5·15	4·23	—	100	12 9/16	5 1/2	45 7/16	107 9/16	—	—	—
'28 ..	5·96	4·48	3·32	—	100	10 31/32	5 1/2	45 7/8	111 5/32	—	—	—
'29 ..	6·75	4·87	3·21	—	100	10 1/4	5 1/2	44 3/4	107 21/32	—	—	—
'30 ..	6·52	4·54	3·21	—	100	9 27/32	5 1/2	44 1/2	102 3/16	—	—	—
'31 ..	3·63	3·10	2·33	—	100	9 1/8	5 1/2	37 19/32	83 3/8	—	—	—
'32 ..	3·97	3·34	2·39	—	100	8 5/8	5 1/2	35 1/2	75 1/16	—	—	—
'33 ..	3·43	2·94	2·48	—	100	8 11/32	5 1/2	31 7/8	75 19/32	—	—	—
'34 ..	3·28	2·65	2·45	—	100	7 13/16	5 1/2	31 1/2	79 13/32	—	—	—
'35 ..	3·51	2·88	2·32	—	100	7 5/8	5 1/2	32 1/4	73 5/32	—	—	—
'36 ..	3·77	2·76	2·34	—	100	7 5/8	5 3/4	37 9/16	78 27/32	—	—	—
'37 ..	4·52	3·71	3·14	—	100	7 25/32	5 3/4	58 3/8	103 7/32	—	—	—
'38 ..	4·08	3·49	3·22	—	100	8	5 3/4	61 3/32	94 5/16	—	—	—
'39 ..	5·00	3·71	3·61	—	100	8 1/8	5 3/4	57 9/16	107 9/32	—	—	—
'40 ..	5·79	5·68	5·31	—	100	9 7/8	5 3/4 †	106 29/32	169 15/16	—	—	—
'41 ..	6·97	5·95	5·93	—	100	13 1/32	5 3/4 †	191 1/16	214 7/16	—	—	—
'42 ..	7·77	7·00	7·07	—	102 1/2	13 1/2	5 3/4 †	235 1/8	236 1/4	—	—	—
'43 ..	8·93	7·51	7·61	—	107 1/2	13 1/2	5 3/4 †	269	246 1/4	—	—	—
'44 ..	8·31	6·78	6·83	—	107 1/2	15 1/4	6 †	222 15/16	273 15/16	—	—	—
'45 ..	6·23	5·33	5·38	—	107 1/2	15 1/4	6 †	190 1/2	235 1/4	—	—	—
'46 ..	5·81	5·21	5·20	—	107 1/2	16 1/8	6 †	184 7/8	258 1/2	—	—	—
Average 1904–13	BASE, 1922			—	60	10 5/8	3	38	56	—	—	—
1890–99				—	53	8 1/4	4 3/8	40	45	—	—	—
'78–87				—	62	12 1/2	6	47	47	—	—	—
'67–77				—	92	14	7 1/4	60	54	—	—	—
	Index Numbers (or Percentages) of Prices, the Average of 1867–77 being 100											
1922 ..	‡ 100	‡ 100	‡ 100	100	134	102	128	143		1,339	3,408	5,873
'25 ..	63	79	106	83	109	96	79	150		1,292	3,691	6,120
'26 ..	58	90	107	85	109	95	78	137		1,235	3,376	5,643
'27 ..	46	82	106	78	109	90	76	134		1,276	3,311	5,477
'28 ..	37	71	83	64	109	78	76	138		1,256	3,202	5,366
'29 ..	42	77	81	67	109	73	76	134		1,190	3,047	5,143
'30 ..	41	72	81	65	109	70	76	129		1,034	2,487	4,313
'31 ..	23	50	60	44	109	65	76	106		890	2,094	3,673
'32 ..	25	53	60	46	109	62	76	97		855	2,062	3,571
'33 ..	22	47	62	44	109	60	76	94		837	2,121	3,529
'34 ..	21	42	62	42	109	56	76	97		839	2,176	3,635
'35 ..	22	46	60	43	109	54	76	92		871	2,298	3,745
'36 ..	24	42	60	42	109	54	79	102		925	2,414	3,945
'37 ..	28	59	79	55	109	56	79	142		1,081	2,821	4,581
'38 ..	26	55	81	54	109	57	79	136		921	2,471	4,071
'39 ..	31	60	91	61	109	58	79	145		964	2,663	4,247
'40 ..	36	90	133	86	109	70	79	243		1,285	3,645	5,760
'41 ..	44	94	150	96	109	93	79	356		1,438	4,004	6,379
'42 ..	49	111	178	113	111	96	79	413		1,564	4,153	6,812
'43 ..	56	119	199	122	117	96	79	452		1,715	4,354	6,978
'44 ..	52	107	172	110	117	109	83	436		1,776	4,619	7,221
'45 ..	39	84	135	86	117	109	83	373		1,753	4,730	7,375
'46 ..	36	82	131	83	117	115	83	389		2,177	5,696	8,365

* Prior to 1922, Kerosene Burning Oil (in barrels), base period 1873–77; from 1922 c.i.f. values per imperial gallon of Motor Spirit, Kerosene (Burning Oil) and Gas Oil, base period 1922.

† Nominal.

‡ Index numbers not included in the general average.

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Fitting Growth and Frequency Curves by the Method of Frequency Moments

By Herbert S. Sichel

Part I

The fitting of growth and frequency functions by least squares and moments consists of deriving and solving a system of equations—one equation for each constant of the curve.

Quite often the derivation and solution of these equations for either of the conventional methods is difficult, laborious and sometimes impossible.(1) (2) In such cases it may be advisable to use a simpler system of equations obtained by equating the sum of the nth powers of observations on the dependent variable u_x to an appropriate integral (or sum) based on the nth power of the ordinate y_x of the fitted curve.

If the observations are taken at regular intervals of unit distance we have

$$J_n = \sum_{x_1}^{x_k}(u_x)^n = \sum_{x_1}^{x_k}(y_x)^n \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

for the case of a finite sum and

$$J_n = \sum_{x_1}^{x_k} w_x(u_x)^n = \int_{x_1-\frac{1}{2}}^{x_k+\frac{1}{2}} y^n dx \quad . \quad . \quad . \quad . \quad . \quad (2)$$

for the case of an integral, where w_x a weight to be attached to the observation. The moments of an area below a frequency curve about the abscissa are given by the relation

$$n \times (n-1)\text{th moment about abscissa} = \int y^n dx.$$

For reason of analogy, therefore, the quantity J_n is hereafter called the "nth frequency moment."

When applying equation (2) in practice we have to bear in mind that the sum of isolated ordinates is equated to an area. A suitable quadrature formula will remove this deficiency. Elderton gives such a formula in *Frequency Curves and Correlation* on p. 28(3). Consequently the first and last four ordinates of the original series, and, of course, the powers of the ordinates, have to be multiplied by the weights

$$\left.\begin{aligned} w_1 = w_k &= 1{\cdot}12205 \\ w_2 = w_{k-1} &= \cdot 75885 \\ w_3 = w_{k-2} &= 1{\cdot}15781 \\ w_4 = w_{k-3} &= \cdot 96129 \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

All the remaining weights are unity. If there is high contact on one end of the experience the adjustments need only be made to the other end. If both ends have high contact no adjustment is necessary.

The phenomena of growth or decay, when plotted, usually have high contact on one end. If the range of the observed data does not go quite as far as the start of the growth we can roughly approximate the missing initial observations. This step is of importance as it simplifies the formulae for the unknown constants.

The first example (Table 1, columns 4 and 5) refers to an experiment of W. B. Bottomley,(4) showing the growth of duckweed without peat-auximone. The observations reveal a typical Malthusian growth. In order to establish high contact at the start, the hypothetical observations are extrapolated by dividing the first observation by the common ratio of the geometric progression, etc. The common ratio is easily found by dividing each pair of subsequent observations and averaging. For this example it is roughly 1·65.

As the ordinates correspond to an exact number of weeks and the mathematical expression to be fitted is a geometrical progression (Malthusian growth), equation (1) should be used.

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If we take the independent variable of the last observation as

$$x_1 = 0$$

and extend the lower limit to

$$x_k = \infty$$

we have

$$J_n = \sum_0^\infty b^n A^{nx} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and

$$J_1 = \frac{b}{1-A}$$

$$J_2 = \frac{b^2}{1-A^2}$$

$$\rho_1 = \frac{J_1^2}{J_2} = \frac{1+A}{1-A}$$

$$\left.\begin{aligned} \therefore A &= \frac{\rho_1 - 1}{\rho_1 + 1} \\ b &= (1-A)J_1 \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The full calculation is set out in Table I. Columns (4) and (5) give the original series, columns (2) and (3) the first and second powers of the original and extrapolated observations. Substitution of the values found for J_1 and J_2 into equations (5) yields

$$\begin{aligned} y &= 1017{\cdot}31(0{\cdot}59029)^x \\ &= 14{\cdot}996(0{\cdot}59029)^{-t} \end{aligned}$$

TABLE I

(1) $x = 8 - t$	(2) u_x	(3) $(u_x)^2$	(4) Weeks t	(5) Number of fronds observed	(6) Calculated	(7) Deviation "v" (Method of Frequency Moments)		(8) Deviation "v" (Method of Least Squares)	
15	1	1							
14	1	1							
13	2	4							
12	3	9							
11	4	16							
10	7	49							
9	12	144							
8	20	400	0	20	15	+5	..	+7	..
7	30	900	1	30	26	+4	..	+8	..
6	52	2,704	2	52	43	+9	..	+14	..
5	77	5,929	3	77	73	+ 4	..	+11	..
4	135	18,225	4	135	124	+11	..	+21	..
3	211	44,521	5	211	209	+ 2	..	+13	..
2	326	106,276	6	326	354	..	−28	..	−17
1	550	302,500	7	550	600	..	−50	..	−45
0	1,052	1,106,704	8	1,052	1,017	+35	..	+20	..
	$J_1 =$ 2,483	$J_2 =$ 1,588,383				+70	−78	+94	−62

The goodness of fit can be gauged by a comparison with a corresponding least square graduation the deviations of which are shown in column (8). It was deemed unnecessary, for this purpose, to work out a preliminary graduation for the correct weights. Instead, the raw observation squares were used. The results of the different tests were:

Method	Σv	$\Sigma \lvert v \rvert$	Σv^2	χ^2
Frequency moments	− 8	148	4,772	12·97
Least squares	+ 32	156	3,754	23·04

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From a strictly theoretical point of view the χ^2-test is not applicable, but it still conveys a good idea of the fit to growth data. Taking into account not only the sum of the deviation squares, but also the sum of the deviations with and without signs, and χ^2, we may safely say that the above fit is not inferior to a least square graduation.

The following example is taken from investigations of His,(5) giving the mean length of the unborn child in monthly intervals. As so many growth observations can be fitted by a Gompertz curve,

$$y = a\, exp(-be^{-cx})$$

was tried and, as can be seen from the results, found to be successful.

Using J_n in its integral form of equation (2) and putting

$$x_k = -\tfrac{1}{2}$$

and

$$x_1 = -\infty$$

we find

$$J_n = a^n \int_{-\infty}^{0} exp(-nbe^{-cx})\, dx \qquad . \quad . \quad . \quad . \quad . \quad (6)$$

the solution of which is

$$J_n = \frac{a^n}{c}\left[-Ei(-nb)\right]$$

$$\left.\begin{aligned} \therefore \quad \alpha_1 = \frac{J_1 J_3}{J_2^2} &= \frac{Ei(-b)\, Ei(-3b)}{[Ei(-2b)]^2} = \varphi(b) \\ a &= \frac{J_2}{J_1}\frac{Ei(-b)}{Ei(-2b)} \\ c &= \frac{a}{J_1}\left[-Ei(-b)\right] \end{aligned}\right\} \qquad . \quad . \quad . \quad . \quad . \quad (7)$$

The exponential integral $Ei(-z)$ can readily be found in Jahnke and Emde's(6) *Mathematical Tables*. With the help of these the approximate nature of "b" can be established by a few trials. Three to five values of $\varphi(z)$ in the neighbourhood of the approximate $\varphi(b)$ are calculated from the tabulated $Ei(-z)$ and the exact "b" is then found by inverse interpolation.

The calculation of J_1, J_2 and J_3 is essentially the same as before, but as we use integrals we must adjust the last four observations and their second and third powers *after* having squared and cubed the *original* figures. The adjustments were given in formula (3).

TABLE II

(1) $x = t - 10{\cdot}5$	(2) $w_x u_x$	(3) $w_x(u_x)^2$	(4) $w_x(u_x)^3$	(5) Months t	(6) Length (in mm.) observed	(7) Calculated	(8) Deviation "v"	
−10·5	0·0	0	0	0	0	0	..	..
− 9·5	7·5	56	422	1	7·5	6	+ 2	..
− 8·5	40·0	1,600	64,000	2	40	32	+ 8	..
− 7·5	84·0	7,056	592,704	3	84	91	..	− 7
− 6·5	162·0	26,244	4,251,528	4	162	176	..	−14
− 5·5	275·0	75,625	20,796,875	5	275	266	+ 9	..
− 4·5	352·0	123,904	43,614,208	6	352	344	+ 8	..
− 3·5	386·4	155,348	62,450,020	7	402	403	..	− 1
− 2·5	512·9	227,219	100,658,045	8	443	445	..	− 2
− 1·5	358·2	169,060	79,796,151	9	472	473	..	− 1
− 0·5	549·8	269,404	132,008,060	10	490	492	..	− 2
	$J_1 =$ 2,727·8	$J_2 =$ 1,055,516	$J_3 =$ 444,232,013				+27	−27

$$\alpha_1 = \frac{J_1 J_3}{J_2^2} = 1{\cdot}0877 = \varphi(b).$$

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A few trials with the help of the $Ei(-z)$ table lead to the approximation

$$\cdot 04 < b < \cdot 06.$$

Tabulating $\varphi(z)$ in the neighbourhood of $\varphi(b)$ gives

z		$\varphi(z)$
·04	.	1·0831
·05	.	1·0877
·06	.	1·0917

Luckily $z = \cdot 05 = b$ already provides the solution in this particular case. Usually we have to find "b" by inverse interpolation. Finally we find

$$\begin{aligned} y &= 523{\cdot}86\ exp(-{\cdot}05000e^{-{\cdot}47395x}) \\ &= 523{\cdot}86\ exp(-7{\cdot}2481e^{-{\cdot}47395t}). \end{aligned}$$

The agreement of the observed and graduated data is good.

No paper on growth curves would be complete without the famous "logistic." The method of frequency moments was therefore applied to the fitting of a logistic to the population growth of the United States of America during the period 1790–1940.

If the equation of the logistic curve is

$$y = \frac{A}{1 + Be^{-cx}}$$

and

$$\begin{aligned} x_k &= -\tfrac{1}{2} \\ x_1 &= -\infty \end{aligned}$$

formula (2) becomes

$$J_n = A^n \int_{-\infty}^{0} \frac{1}{(1 + Be^{-cx})^n}\, dx \qquad . \quad . \quad . \quad . \quad (8)$$

Solving the integral after expansion gives

$$\begin{aligned} J_n = \frac{A^n}{c}\Big[&- \log q + (n-1)q - \frac{(n-1)(n-2)}{4} q^2 \\ &+ \frac{(n-1)(n-2)(n-3)}{18} q^3 \ . \ . \ . \ . \ . - (n-1) + \frac{(n-1)(n-2)}{4} \\ &- \frac{(n-1)(n-2)(n-3)}{18} \ . \ . \ . \ . \ . \Big] \qquad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9) \end{aligned}$$

where $1 + \frac{1}{B} = \frac{1}{q}$.

From formula (9) we find

$$\left.\begin{aligned} \alpha_1 &= \frac{\log q(\log q - 2q + \frac{1}{2}q^2 + \frac{3}{2})}{(\log q - q + 1)^2} \\ c &= \frac{(\log q)^2}{\rho_1(q - 1 - \log q)} \\ A &= -\frac{cJ_1}{\log q} \end{aligned}\right\} \qquad . \quad . \quad . \quad . \quad . \quad (10)$$

where $\alpha_1 = \dfrac{J_1 J_3}{J_2^2}$

and $\rho_1 = \dfrac{J_1^2}{J_2}$.

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The first of the three equations (10) is solved for q by the "regula falsi."

But
$$1 + \frac{1}{B} = \frac{1}{q}$$

$$\therefore \quad B = \frac{q}{1-q}$$

As the logistic runs into a geometric progression at its lower end, we may adopt the same procedure as in our first example. The approximate common ratio is 1·345 and thus the initial missing data can readily be computed.

Table III gives the complete calculations:

TABLE III

(1) $x = \frac{1}{10}t - 16{\cdot}5$	(2) $w_x u_x$	(3) $w_x(u_x)^2$	(4) $w_x(u_x)^3$	(5) Year	t	(6) Population $\times 10^6$ observed	(7) Calculated	(8) Deviation "v"	
− 33·5	·01	·00	·00						
− 32·5	·02	·00	·00						
− 31·5	·03	·00	·00						
− 30·5	·04	·00	·00						
− 29·5	·06	·00	·00						
− 28·5	·08	·01	·00						
− 27·5	·11	·01	·00						
− 26·5	·15	·02	·00						
− 25·5	·20	·04	·01						
− 24·5	·27	·07	·02						
− 23·5	·36	·13	·05						
− 22·5	·49	·24	·12						
− 21·5	·66	·44	·29						
− 20·5	·89	·79	·70						
− 19·5	1·20	1·44	1·73						
− 18·5	1·61	2·59	4·17						
− 17·5	2·17	4·71	10·22						
− 16·5	2·92	8·53	24·90						
− 15·5	3·93	15·44	60·70	1790	10	3·929	3·895	− ·034	..
− 14·5	5·31	28·20	149·72	1800	20	5·308	5·304	− ·004	..
− 13·5	7·24	52·42	379·50	1810	30	7·240	7·207	− ·033	..
− 12·5	9·64	92·93	895·84	1820	40	9·638	9·752	..	+ ·114
− 11·5	12·87	165·64	2,131·75	1830	50	12·866	13·131	..	+ ·265
− 10·5	17·07	291·38	4,973·94	1840	60	17·069	17·564	..	+ ·495
− 9·5	23·19	537·78	12,471·03	1850	70	23·192	23·295	..	+ ·103
− 8·5	31·44	988·47	31,077·61	1860	80	31·443	30·558	− ·885	..
− 7·5	38·56	1,486·87	57,333·85	1870	90	38·558	39·537	..	+ ·979
− 6·5	50·16	2,516·03	126,203·84	1880	100	50·156	50·307	..	+ ·151
− 5·5	62·95	3,962·70	249,452·12	1890	110	62·948	62·763	− ·185	..
− 4·5	76·00	5,776·00	438,976·00	1900	120	75·995	76·572	..	+ ·577
− 3·5	88·41	8,131·01	747,808·83	1910	130	91·972	91·189	− ·783	..
− 2·5	122·39	12,938·09	1,367,686·16	1920	140	105·711	105·919	..	+ ·208
− 1·5	93·16	11,437·81	1,404,219·86	1930	150	122·775	120·044	− 2·731	..
− 0·5	147·45	19,376·20	2,546,225·80	1940	160	131·410	132·962	..	+ 1·552
	801·04 J_1	67,815·99 J_2	6,990,088·76 J_3					− 4·655	+ 4·444

$$\rho_1 = 9{\cdot}461853 \qquad B = {\cdot}346464$$
$$\alpha_1 = 1{\cdot}21751 \qquad c = {\cdot}316784$$
$$q = {\cdot}257314 \qquad A = 186{\cdot}935$$

$$y = \frac{186{\cdot}935}{1 + {\cdot}34646e^{-{\cdot}31678x}}$$

$$P_t = \frac{186{\cdot}935}{1 + 64{\cdot}515e^{-{\cdot}031678t}} \qquad (11)$$

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The same data have also been graduated by Pearl, Reed and Kish,(7) using a least square procedure as illustrated in Pearl's *Introduction to Medical Biometry and Statistics*. The goodness of fit of the frequency moment method and of the least square method, as given by the above authors, is compared in the following table:

Method	Σv	$\Sigma \lvert v \rvert$	Σv^2	*Number of deviations*		χ^2
				+ve	−ve	
Frequency moments	−0·211	9·099	12·996	9	7	·164
Least square	−2·295	9·105	12·408	6	10	·181

Taking all criteria into consideration one can safely conclude that the "Method of Frequency Moments" gives an equally good, if not better fit. Incidentally, the constants to the same logistic, based on the 1790–1910 period only, and calculated by the method of Frequency Moments, do not differ materially from those just found.

TABLE IV

Constant	*Period* 1790–1910	*Period* 1790–1940
A_t	186·15	186·93
B_t	64·11	64·51
c_t	·0317	·0317

PART II

The method of Frequency Moments can also be usefully employed for the fitting of certain frequency curves. Let us begin with the Gaussian curve:

$$y = be^{-ax^2}.$$

Using the limits

$$x_1 = -\infty$$
$$x_k = +\infty$$

equation (2) becomes

$$J_n = b^n \int_{-\infty}^{+\infty} e^{-nax^2}\, dx = b^n \sqrt{\frac{\pi}{na}}$$

$$\left.\begin{aligned} \therefore a &= \frac{2\pi}{\rho_1^2} \\ b &= \frac{\sqrt{2}N}{\rho_1} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots \quad (12)$$

where $\rho_1 = \dfrac{J_1^2}{J_2}$

$J_1 = N =$ Total frequency.

The equation of the normal curve of error can consequently be written

$$y = \frac{\sqrt{2}N}{\rho_1} e^{-\frac{2\pi}{\rho_1^2}x^2} \quad \ldots\ldots\ldots\ldots \quad (13)$$

This is a very important result, as will be shown presently.

The customary Gaussian equation is

$$y = \frac{N}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}} \quad \ldots\ldots\ldots\ldots \quad (14)$$

By comparing (13) and (14) it follows that the standard deviation

$$\sigma = \frac{1}{2\sqrt{\pi}} \rho_1 = .2821\rho_1 \quad \ldots\ldots\ldots\ldots \quad (15)$$

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The hitherto undefined quantity ρ_1 emerges as a measure of dispersion.

When calculating ρ_1 we do not *appear* to use the variate values at all, but there is, of course, a functional relationship between the frequencies and the variate values which is obscured by the grouping of unit intervals.

The new method is specially useful in obtaining graduations of statistics where ordinary moments become impossible to use, *i.e.* the Cauchy distribution and Student distributions of $n = 2, 3, 4$ and 5.

With the help of a random sampling number table(8) a sample of 1,000 was drawn from a population defined by the law

$$P(x) = \frac{\sqrt{2}}{\pi}\left(1 + \frac{x^2}{2}\right)^{-2}$$

The resulting statistics is shown in the second column of Table V.

As the experience shows high contact on both ends the usual corrections of part I fall away. On the other hand, the statistics to be dealt with are no longer isolated terms but frequencies. In order to overcome this difficulty midordinates of the respective frequency groups are found by Hardy's(9) formula

$$u_x = f_x - \frac{1}{24}\Delta^2 f_{x-1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

where f_x represent the original frequencies. The midordinates u_x are then handled in the same manner as described in part I. Corrections to the ends are, of course, omitted and all w_x become unity.

A particular feature of the method of Frequency Moments is the decreasing weight given to the tails of the experience with J_n's of higher orders, a drawback which becomes especially marked in the case of leptokurtic curves. This difficulty can be overcome by using sets like $J_{\frac{1}{2}}$, J_1, $J_{\frac{3}{2}}$ or J_1, $J_{\frac{3}{2}}$, J_2 instead of J_1, J_2, J_3 for calculating the constants.

Table V gives the full calculation.

TABLE V

Central x	Frequency f_x	u_x	$(u_x)^{\frac{3}{2}}$	$(u_x)^2$	Graduated frequency	Deviation "v"		
under	0	..	..	..	2	..	− 2	
− 7	0	0·0	0·00	0·00	1	..	− 1	
− 6	1	0·9	0·86	0·81	2	..	− 1	0·64
− 5	4	4·0	8·00	16·00	3	+ 1	..	
− 4	6	5·8	13·98	33·64	6	—	—	
− 3	14	12·4	43·65	153·76	16	..	− 2	0·25
− 2	61	57·4	435·09	3,294·76	52	+ 9	..	1·56
− 1	194	190·0	2,618·20	36,100·00	193	+ 1	..	0·01
0	424	442·8	9,316·51	196,071·84	418	+ 6	..	0·09
+ 1	202	198·7	2,801·67	39,481·69	216	..	−14	0·91
+ 2	59	54·6	403·49	2,981·16	58	+ 1	..	0·02
+ 3	23	22·3	105·26	497·29	18	+ 5	..	1·39
+ 4	3	2·1	3·04	4·41	7	..	− 4	
+ 5	4	4·0	8·00	16·00	3	+ 1	..	
+ 6	4	4·1	8·28	16·81	2	+ 2	..	0·60
+ 7	1	0·9	0·86	0·81	1	—	—	
over	0	..	..	..	2	..	− 2	
	1,000	1,000·0 J_1	15,766·89 $J_{\frac{3}{2}}$	278,668·98 J_2		+26	−26	$\chi^2 = 5{\cdot}47$ $P = 0{\cdot}37$

$$\text{Mean} = + 0{\cdot}044$$

$$\rho_1 = \frac{J_1^2}{J_2} = 3{\cdot}58849$$

$$\alpha_{\frac{3}{2}} = \frac{J_1 J_2}{J_{\frac{3}{2}}^2} = 1{\cdot}12098$$

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Graduating by a Pearson Type VII curve leads to

$$J_n = 2y_0{}^n \int_0^\infty \left(1 + \frac{x^2}{a^2}\right)^{-nm} dx \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$$J_n = a\sqrt{\pi}\, y_0{}^n \frac{\Gamma(nm - \frac{1}{2})}{\Gamma(nm)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

$$\left.\begin{aligned} \frac{J_1 J_2}{J_{\frac{3}{2}}^2} &= \frac{\Gamma(m - \frac{1}{2})\,\Gamma(2m - \frac{1}{2})\,[\Gamma(\frac{3}{2}m)]^2}{[\Gamma(\frac{3}{2}m - \frac{1}{2})]^2\,\Gamma(m)\,\Gamma(2m)} \\ a &= \frac{\rho_1}{\sqrt{\pi}} \frac{\Gamma(2m - \frac{1}{2})}{\Gamma(2m)} \left[\frac{\Gamma(m)}{\Gamma(m - \frac{1}{2})}\right]^2 \\ y_0 &= \frac{J_1\,\Gamma(m)}{a\sqrt{\pi}\,\Gamma(m - \frac{1}{2})} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (19)$$

Calculating (19) numerically gives

$$y = 455{\cdot}25(1 + 0{\cdot}6169x^2)^{-1{\cdot}778} \quad . \quad . \quad . \quad . \quad . \quad (20)$$

The graduated frequencies were computed after the origin was fixed at the mean. The χ^2-test shows that the fit is satisfactory.

As a final example of fitting frequency distributions by the method of Frequency Moments, a set of statistics was taken from a paper of the author.[10] The data refer to experimental tests on the accuracy of auriferous ore sampling as carried out underground in the course of ordinary routine technique with hammer and chisel.

Percentage errors	*Frequencies*
− 80% to − 40%	..
− 40% ,, 0%	32
0% ,, + 40%	60
+ 40% ,, + 80%	25
+ 80% ,, + 120%	8
+ 120% ,, + 160%	1
Total . . .	126

The experience suggests a distinctly asymmetrical distribution rising abruptly in the beginning and having high contact at the upper end.

In finding a midordinate for the first group we are presented with a difficulty, as formula (16) is only applicable to ends with high contact. Assuming that the curve to be found can be approximated by a fourth degree parabola passing through the start of the first group we have

$$\int_0^2 u_x dx = \int_0^2 (ax^4 + bx^3 + cx^2 + ex)dx$$

$$= \frac{32}{5}a + 4b + \frac{8}{3}c + 2e.$$

Expressing a, b, c and e in terms of midordinates gives:

$$\int_0^2 u_x dx = \frac{1}{6300}[5{,}285u_{\frac{1}{2}} + 6{,}265u_{\frac{3}{2}} + 231u_{\frac{5}{2}} - 5u_{\frac{7}{2}}] \quad . \quad . \quad (21)$$

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Solve for the first midordinate

$$u_{\frac{1}{2}} = \frac{1}{5,285}[6,300\int_0^2 u_x dx - 6,265u_{\frac{3}{2}} - 231u_{\frac{5}{2}} + 5u_{\frac{7}{2}}] \quad . \quad . \quad . \quad (22)$$

In practice, therefore, we find the second, third and fourth midordinates by formula (16). For $\int_0^2 u_x dx$ we substitute the sum of the first two frequencies.

In our example:

$$\begin{aligned} \int_0^2 u_x dx &= 92{\cdot}0 \\ u_{\frac{3}{2}} &= 62{\cdot}6 \\ u_{\frac{5}{2}} &= 24{\cdot}2 \\ u_{\frac{7}{2}} &= 7{\cdot}6 \\ \therefore \quad u_{\frac{1}{2}} &= 34{\cdot}4 \end{aligned}$$

The powers of the midordinates are set out in the following table:

TABLE VI

u_x	$(u_x)^2$	$(u_x)^3$
34·4	1,183·36	40,707·584
62·6	3,918·76	245,314·376
24·2	585·64	14,172·488
7·6	57·76	438·976
·7	·49	·343

Previously we found the areas by adding the midordinates. This procedure is only permissible in the case of high contact at both ends of the curve. If the curve rises abruptly, a suitable quadrature formula must be used.

Elderton[3] gives in *Frequence Curves and Correlation*:

$$\int_0^1 u_x dx = \frac{1}{5,760}[5,178u_{+\frac{1}{2}} + 308(u_{-\frac{1}{2}} + u_{+\frac{3}{2}}) - 17(u_{-\frac{3}{2}} + u_{+\frac{5}{2}})] \quad . \quad . \quad (23)$$

This formula can be applied to all groups but the first and last two, while formula (21) gives the first two areas.

Combining (21) and (23) and bearing in mind that there exists high contact at the upper end we finally get:

$$\int_0^n u_x dx = {\cdot}835938u_1 + 1{\cdot}044965u_{\frac{3}{2}} + {\cdot}986146u_{\frac{5}{2}} + 1{\cdot}002157u_{\frac{7}{2}} + u_{\frac{9}{2}} + u_{\frac{11}{2}} \ldots\ldots + u_{\frac{2n-1}{2}} \quad . \quad . \quad (24)$$

By applying formula (24) to the midordinates of Table VI we arrive at the correct Frequency Moment, Table VII.

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TABLE VII

$w_x u_x$	$w_x(u_x)^2$	$w_x(u_x)^3$
28·7	989·2	34,029·0
65·4	4,095·0	256,344·3
23·9	577·5	13,976·1
7·5	57·9	439·9
·7	·5	·3
$J_1 = 126·2$	$J_2 = 5{,}720·1$	$J_3 = 304{,}789·6$

$$\rho_1 = 2·78429$$

$$\alpha_1 = \frac{J_1 J_3}{J_2^2} = 1·17558.$$

The logarithmic frequency function

$$y = y_0 \, exp \, [- a(\log x - b)^2] \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

was chosen to graduate the above data.

We have

$$J_n = y_0^n \int_0^\infty exp \, [- na(\log x - b)^2] dx$$

$$= y_0^n \sqrt{\frac{\pi}{na}} \, e^{b + \frac{1}{4na}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

From (26)

$$\left.\begin{aligned} a &= \frac{1}{12 \log_e \left(\frac{\sqrt{3}}{2} \alpha_1 \right)} \\ b &= \log_e \left(\rho_1 \sqrt{\frac{a}{2\pi}} \, e^{-\frac{3}{8a}} \right) \\ y_o &= J_1 \sqrt{\frac{a}{\pi}} \, e^{-(b + \frac{1}{4a})} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (27)$$

Numerical evaluation leads to the equation

$$y = 65·847 \, exp \, [- 4·6501 \, (\log x - ·79286)^2] \quad . \quad . \quad . \quad (28)$$

In order to compare ungraduated and graduated figures it is necessary to find a point of reference by superimposing the mean of the graduating function upon the mean of the raw statistics.

We find:

Mean of statistics . . . = + 23·8096%

Mean of Frequency Function (28) $= e^{b + \frac{3}{4a}}$.

$= 2·5964$

In Table VIII graduated and ungraduated frequencies are compared. The results of a graduation by the method of moments is also given.

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TABLE VIII

Percentage errors	*Observed*	*Graduated [Eq. (28)]*	*Graduated [Method of Moments]*
− 80% to − 40%	...	..	1
− 40% ,, 0%	32	33	33
0% ,, + 40%	60	58	57
+ 40% ,, + 80%	25	26	27
+ 80% ,, + 120%	8	7	7
+ 120% ,, + 160%	1	2	1
	126	126	126

The relative tests for goodness of fit are given below. The first and last two groups were combined in order to meet the requirements of the χ^2-test.

Method	Σv^2	χ^2
Frequency Moments	8	·14
Moments	16	·55

Summary

To overcome the difficulties and excessive labour in fitting growth observations by the least square technique, the method of Frequency Moments has been developed in this paper.

Data were successfully fitted to exponential, Gompertz and logistic functions.

Symmetrical and skew frequency distributions can also be fitted by the new method, which is specially useful in cases where ordinary moments do not exist.

The Frequency Moments constitute a set of parameters, defining frequency distributions, and possess invariantive properties.

In particular, ρ_1 represents a measure of dispersion.

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Statistical and Social Inquiry Society of Ireland: Centenary Celebrations

On November 23, 1847, the Dublin Statistical Society was created for the purpose of "promoting the study of statistical and economical science." The interesting story of its early development, its merging in 1855 with the Social Inquiry Society, and, after a period of decline, its subsequent recovery to its present high position among the learned societies is well told by Dr. Collison Black in the Society's recently published centenary volume.

The centenary celebrations of the Society took place in Dublin in October, 1947, when special meetings and various functions, public and private, were held. The following programme shows the more important events which took place, and gives some idea of the welcome meted out with characteristically Irish hospitality to the visitors, who included Professor Corrado Gini (Italy), Don José Ros and Don Antonio de Miguel of the Spanish National Institute of Statistics, Professor Findlay Shirras (United Kingdom), Dr. D. Elekes, President of the Central Hungarian Statistical Office, Dr. L. Bene, Director of the Municipal Bureau of Statistics of Budapest, and Dr. C. Oswald George, representing the Royal Statistical Society.

Oct. 6th	(evening)	Reception by the President of the Society in the Dixon Hall, Trinity College.
,, 7th	(morning)	Paper by the President of the Society, followed by discussion.
	(afternoon)	Visit to Guinness' brewery.
	(evening)	Government reception (Mr. and Mrs. de Valera at Iveagh House).
,, 8th	(morning)	Paper by Dr. Joseph Brennan, Governor of the Central Bank, on "Some Aspects of Cheap Money," followed by discussion.
	(afternoon)	Visit to Dail and Trinity College.
,, 9th	(morning)	Paper by Dr. Corrado Gini on "Statistics of Births" followed by discussion.
	(afternoon)	Reception and Tea at Arus an Uachtaráin. (The President of Eire and Mrs. O. Ceallaigh.)
	(evening)	Centenary Banquet (Toast of the Society moved by the Tanaiste, Mr. Seán Lemass).
,, 10th	(afternoon)	Visit to National and Dublin Municipal Art Galleries.
	(evening)	Visit to a theatre.

A brief summary of the President's profound and stimulating paper, which dealt with many points of interest to all statisticians, is given below.

Some Reflections on Tendencies in the Theory and Practice of Statistics in Ireland and Elsewhere

By Dr. R. C. Geary

Dr. Geary began by commenting on the inauguration in several countries of official estimations of national income and expenditure, which he regarded as the most important development in economic statistics in recent years; he dealt in some detail with the Eire estimates, past, present and future, and made some pertinent remarks on the League of Nations Committee's suggestion that national income and expenditure statistics should be presented as a set of self-balancing accounts. He then dealt with the possibility of preparing national accounts calculated in terms of fixed prices, and from these deriving indices of the purchasing power of money as substitutes for the present defective wholesale price index numbers.

The next point considered was the concept of relationship between economic time series and its potentialities and limitations for economic forecasting and economic planning; although suggesting that statisticians would do well to emphasize the experimental character of the work in this field, he indulged in some interesting speculations about the probable trend of research.

Passing to problems of sampling, Dr. Geary cleared away many popular misconceptions while explaining exactly what could and what could not be obtained from samples, and the possibility by this means of ensuring a much-to-be-desired speeding up in the publication of official

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statistics. He pointed out the advantages of stratification, and repeated the suggestion he had made at the recent conference at Montreal that the I.L.O. should be empowered to conduct inquiries on its own initiative into the reliability of national statistics. He mentioned the practice adopted in the Irish National Income White Paper of labelling important items in four reliability categories, "firm figures," "good estimates," "rough estimates," and "guesses," and then discussed the statistics put forward as a basis for the international distribution of foodstuffs.

Dr. Geary had some illuminating remarks to pass on the organization of government statistical offices. He stressed the desirability of having a flow of members of the ordinary administrative staff into and out of the statistical office, so that a knowledge of the nature and usefulness of statistics might gradually be more widely disseminated among the higher administrative ranks while, at the same time, the statistical office might become more intimately aware of the kind of statistics the administrators needed and could effectively use. The statisticians should, he thought, be inalienably attached to the statistics office, and find their avenue of promotion solely in that office.

He then made some lighthearted but extremely penetrating comments on an associated matter —the Royal Statistical Society's scheme for professional examinations—and said he found the position distinctly Gilbertian: "In other spheres one passes an examination to become a Fellow; in statistics one becomes a Fellow to pass an examination."

The next point covered was the relation and respective spheres of government statistical departments and university or other research institutes, and the mutual advantages to be gained by proper co-ordination between them. He then commented rather sadly on the lack of statistical awareness among even the largest of Irish industrial firms, with the honourable exception of one great firm "renowned among statisticians the world over even more for its association with the illustrious name of 'Student' than for its famous product."

Dr. Geary concluded by reverting to the all-important problem of maximizing the utility of government statistics, and stressing once again the great need of making the administrator statistics-minded, and of inculcating in statisticians a real knowledge of current administrative problems.

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REPORT OF THE COUNCIL

For the FINANCIAL YEAR *ended December* 31*st*, 1946, *and for the* SESSIONAL YEAR *ending July* 10*th*, 1947, *presented at the* ONE HUNDRED AND THIRTEENTH ANNUAL GENERAL MEETING *of the* ROYAL STATISTICAL SOCIETY, *held at the London School of Hygiene and Tropical Medicine, W.C.* 1, *on July* 10*th*, 1947.

THE Council has the honour to submit its One Hundred and Thirteenth Report.

Number of Fellows

During the calendar year 1946 the very large number of 287 new Fellows were elected into the Society (including a few previous Fellows who, under special war circumstances, were restored to the roll). Losses by death, withdrawal and default numbered 56, so that there was a net increase of 231, by far the largest in the history of the Society. The figures set out below reveal the rapid increase that has taken place in the last four years. Between December 31st, 1936, with a Fellowship of 1,049, and the end of 1942, with a roll of 1,079, there was but little change—a slight increase in the pre-war years, a slight falling-off in the first years of the war. Between 1942 and 1946, on the other hand, there has been a net increase of 569, or more than 50 per cent. of the pre-war total. In these four years there has been an entry of 744 Fellows against a loss of 175. The applications for election have continued to be high during the opening months of 1947, and it is likely that within the next two or three years the Society will have doubled its pre-war roll. The Council reports with satisfaction this increase, and the expansion in statistical work and interests that it denotes. It does, however, raise problems peculiar to the day. For instance, the pre-war paper supply has to meet the issue of the JOURNAL to these greatly increased numbers. It has, therefore, so far been impossible to resume the publication of the List of Fellows, customary in pre-war years, although the Council, conscious of its importance, has done much towards its preparation, and hopes to be able to issue it in the near future.

In addition to the numbers given in the table there were 19 Honorary Fellows, including seven who are Presidents for the time being of other Societies.

Calendar Year	Lost by death, withdrawal or default	Elected, or restored to the roll	On the roll at December 31st
1936	64	62	1,049
1937	45	59	1,063
1938	56	76	1,083
1939	39	64	1,108
1940	76	47	1,079
1941	65	60	1,074
1942	69	74	1,079
1943	61	121	1,139
1944	29	159	1,269
1945	29	177	1,417
1946	56	287	1,648

Elections and Restorations

From June 1946 to May 1947, inclusive, 239 Fellows were elected or restored to the roll, and at the end of May 1947 the total number of Fellows was 1,748. The names of Fellows elected from June 1946 to May 1947 are listed in Appendix A.

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Losses by Death

The Council regrets to report that during the sessional year (to May 31st, 1947) the Society lost by death the undermentioned Fellows:—

	Date of election.
*Carter, Eric M.	1890
Crathorne, Arthur R.	1919
Creed, Leslie Edwin	1945
Cudmore, Sedley Anthony	1920
*p*Cunningham, L. B. C., O.B.E., Ph.D.	1946
Epstein, Mortimer, Ph.D.	1919
de Fellner, Professor Frederic	1930
Fisher, Edwin	1937
Fisher, Professor Irving, Ph.D., LL.D.	1900
Frankland, Ernest George	1933
*c**Harvey, Sir Percy, K.B.E., C.B., F.I.A.	1937
*Kirkcaldy, William M.	1894
Kraay, Casper Alexander	1944
MacColl, Hugh Geoffrey, M.A., B.Sc.	1938
Macdonald, John Hutcheson	1902
Newbery, Archibald David	1932
*cp*Rae, George, D.Sc.	1920
Stone, James	1926
Wallis, Percy	1908
White, Bertram Alexander, B.Sc.	1943

* Life Fellow.

c Served on Council.
p Contributed to *Proceedings*.

Dr. S. A. Cudmore, who died suddenly in October 1945, while attending a meeting of the United Nations Food and Agricultural Organization, was for many years principal assistant to Dr. R. H. Coats, Statistician to the Dominion of Canada, and had a wide knowledge of all aspects of Government statistics. In 1935 he was appointed statistician for Palestine, and spent some years there in very successfully organizing a central bureau of statistics, dealing with the various economic and social aspects of life in that country. He returned to Canada to succeed Dr. Coats in 1942 as the Dominion Statistician. He had been a Fellow of the Society for 25 years, and a Member of the International Statistical Institute since 1929.

Dr. L. B. C. Cunningham, who at the time of his death had only recently become a Fellow of the Society, was Superintendent of the Air Warfare Analysis Section of the Ministry of Aircraft Production. With Mr. W. R. B. Hynd he presented a joint paper to a meeting of the Research Section at which auto-correlation in time series was discussed. Further original contributions in the mathematical-statistical field would doubtless have followed, and his death is a loss both to the Research Section and to the Society.

Sir Percy Harvey had a long and distinguished career in the Government service in the department of the Government Actuary. Becoming a Fellow of the Institute of Actuaries in 1913, he joined in the same year the brilliant team of young actuaries which Alfred Watson, who in 1920 became himself the first Government Actuary, was then gathering around him. On Watson's death in 1936 Harvey became Deputy Government Actuary. On the outbreak of war he was seconded to the Ministry of War Transport, in which he served as Joint Statistical Advisor with Sir William Elderton and as Director of Statistics and Intelligence. At the end of 1944 he returned to his old department, as Government Actuary, to take up, amongst many problems, the heavy tasks involved in the current legislation in the field of national insurance. He had served on the Council of the Institute of Actuaries and was a Vice-President in the years 1935 to 1938. He joined the Society in 1937, and was a member of the Council from 1941 until the time of his death. Though the demands on his services must in latter years have been almost overwhelming he spared both time and thought on the Society's behalf. The public service, the actuarial profession and statisticians in many fields of work have suffered a great loss in his early death.

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Professor Irving Fisher, who died in New York at the age of eighty, was one of the distinguished economists of the U.S.A. He was for many years Professor of Political Economy at Yale University, and on retirement from his chair was created Professor Emeritus. A mathematician by training and, therefore, drawn to the statistical aspects of economic science, he devoted much time to the problem of stable money, and particularly applied himself to the preparation and foundation of index numbers. His well-known book, *The Making of Index Numbers*, was published in 1922. He had been a Fellow of the Society for nearly fifty years.

Dr. George Rae served for a short time, after the first World War, as an assistant in the Board of Trade to a former President of the Society, Mr. H. W. Macrosty. The greater part of his life was devoted to the development and use of statistics in the tea and rubber industries, as statistician to Messrs. Harrisons & Crosfield, and to the wider field of economic problems and research upon which his firm's interests impinged. He joined the Society in 1920, presented a paper on the Statistics of the Rubber Industry in 1938, and served on the Council from 1936 to 1941 and again from 1942 to the time of his death. In 1946 he was appointed a Vice-President. Modest and unassuming, he was a man both of ability and personal charm.

Dr. Mortimer Epstein was Editor of the *Statesman's Yearbook* ; Mr. Edwin Fisher, the Chairman of Barclays Bank, had represented in the Society his organization since 1937 ; Mr. A. D. Newbery was a director of Messrs. Richard Clay & Co., for many years the Society's printers.

Meetings of the Society

Following the adoption of the revised Bye-laws the Council has been able to arrange for Ordinary General Meetings to be held in each month from November to June, and to call the Annual General Meeting of the Society in July. A wide variety of subjects has been put before these meetings, which have been largely attended, but the Council would once more urgently remind the many new Fellows that it relies entirely upon *them* for the submission of papers, and for thus being able to frame a programme appropriate to the diverse interests of the Fellowship. The Council has been fortunate in being able to continue to hold all the Society's meetings in the main lecture theatre of the London School of Hygiene and Tropical Medicine.

The following papers have been read:—

1946	
November 27th .	SARGANT FLORENCE, Prof. Statistical Analysis of Joint Stock Company Control.
December 19th .	WISHART, Dr. J. Statistical Aspects of Demobilization in the Royal Navy.
1947	
January 23rd . .	Discussion on Statistics and the Statistician in Industry, opened by Mr. H. T. WEEKS.
February 26th .	TIPPETT, L. H. C. The Study of Industrial Efficiency, with special reference to the Cotton Industry.
March 27th . .	Discussion on The Statistical Basis of Export Targets, opened by Dr. E. C. SNOW.
April 24th . .	MARLEY, Miss J. G., B.A. A Statistical and Economic Survey of Certain Aspects of the Beef Producing, Milk Producing and Cattle Rearing Industries in Great Britain between 1939 and 1945.
May 22nd . .	SHONE, R. M. Iron and Steel Development Plan—Some Statistical Considerations.
June 26th . .	KYD, J. G. The Proposed Third Statistical Account of Scotland.

A Special General Meeting of the Society was held on November 7th, 1946, when it was unanimously resolved that the Society's Petition to the Privy Council for a supplemental charter be withdrawn and the proposed new Bye-laws of the Society were adopted.

The Research Section

With Dr. J. Wishart and Dr. H. E. Daniels re-elected Chairman and Honorary Secretary respectively for the Session the Research Section has held four meetings, at which the following papers have been read:—

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1946	
December 5th .	The Interdependence of Blocks of Transactions, by Mr. J. R. N. Stone.
1947	
January 30th .	The Principles of Biological Assay, by Mr. D. J. Finney.
April 2nd .	The Statistical Investigation of Casualties suffered in Certain Types of Vessels, by Dr. S. Vajda.
May 29th .	Multivariate Analysis, by Dr. M. S. Bartlett.

These meetings were well attended, the average number present being 70.

Arising out of the "Symposium on Auto-Correlation in Time Series" held last Session, the Committee of the Section organized an exhibition of "Mechanical Aids to Statistics" on July 20th, 1946, at Imperial College, South Kensington, and on the same day a demonstration of punched card technique was given at the Q Stats Division of the War Office. Dr. L. J. Comrie introduced the exhibition with a short lecture on the machines. The Research Section is greatly indebted to all those who co-operated in this venture, particularly Professor H. Levy of Imperial College, and the Q Stats Division of the War Office.

The Research Section is also co-operating in an unofficial capacity with the Department of Statistics, University College, London, in the production of a book on Statistical Computation.

The Industrial Applications Section

The work of the Industrial Applications Section, which is organized in Local Groups, has been guided by a Section Committee which has co-ordinated the activities of the Groups and regulated their relationship with the Society. This Committee has consisted of four members appointed by the Council and two representatives of each of the four Local Groups, Dr. B. P. Dudding and Mr. W. J. Jennett being elected as Chairman and Honorary Secretary.

During the session Groups have continued to function in Birmingham, London and Sheffield and a North-Eastern Group has been formed. This new Group is centred on the Tyne and Wear areas and includes a Tees-side sub-Group. Its potentialities for serving a wide range of industry are considerable.

The officers of the Groups are as follows:—

Group	*Chairman*	*Honorary Secretary*
Birmingham and District . . .	Dr. J. W. Rodgers.	Mr. D. J. Desmond.
London	Mr. W. J. Jennett.	Miss J. Keen.
Sheffield	Mr. A. W. Swan.	Mr. J. I. Morley.
North-Eastern	Mr. D. O. Black.	Mr. J. Elliott.
,, (Tees-side) . . .	Dr. G. I. Higson.	Mr. J. T. Richardson.

Notes on the formation of the North-Eastern Group appeared in a number of scientific and technical journals, which have also continued to publish notices of the meetings of the Section. At the end of 1946 the membership numbered about 500, including some 150 Fellows. During the Session 31 meetings have been held, seven in Birmingham, seven in London, seven in Sheffield, four in Newcastle, four in Middlesbrough, one in Lemington-on-Tyne and one in Stockton-on-Tees.

The subjects for discussion have been as follows :—

Birmingham and District Group

1946	
September 18th .	A Review of some Quality Control Methods in the U.S.A.—Mr. W. A. Bennett.
October 23rd .	Market Research—Mr. A. S. Wharton.
November 20th .	Industrial Statistics in America and its Development in Britain—Mr. M. Milbourn.
1947	
January 15th .	Statistical Definitions and their Consequences—Mr. V. E. Gough.
February 19th .	Regression and Correlation—Mr. B. Martin.
March 19th .	Aspects of Statistical Computing—Dr. H. O. Hartley.
April 16th .	Standardization—Mr. W. J. Jennett.

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London Group

1946	
October 4th	Statistics in America—Mr. M. Milbourn.
November 8th	Some Applications of Multiple Correlation—Mr. K. Brownlee, Dr. B. P. Dudding and Mr. D. J. Desmond.
December 6th	Statistics in America—Factory Organization—Mr. W. A. Bennett and Mr. M. Milbourn.
1947	
January 31st	Control Charts Applied to Sales Data—Dr. B. P. Dudding.
March 7th	The Standardization of Symbols and Nomenclature in Quality Control—Mr. R. Banister.
April 11th	Methods of Forecasting and Preventing Accidents—Mr. F. L. Wilkins.
May 9th	Statistical Methods Applied to Component Assemblies—Mr. G. Barnard.

Sheffield Group

1946	
September 26th	What Statistics can do that other Methods cannot do—Mr. A. W. Swan.
October 31st	The Control of Coke Quality by the Shatter Test—Mr. J. Bradwell.
November 28th	The Efficiency of 100 per cent. Inspection—Mr. D. Newman.
1947	
January 27th	Statistics applied in a Bar Rolling Mill—Mr. W. T. Hale.
February 24th	A Statistical Study of 28 Factors affecting Coke Consumption in a Blast Furnace—Mr. G. H. Jowett.
March 24th	The Value of the Factorial Experiment in a Chemical Investigation and its Development—Mr. K. A. Brownlee.
April 21st	The Application of Statistical Technique to Research and Testing—Mr. M. Milbourn.

North-Eastern Group

1946	
December 2nd	The Introduction of Quality Control in the Factory—Dr. B. P. Dudding.
1947	
February 12th	Some Fundamentals of Industrial Statistics—Mr. M. Milbourn.
March 12th	A General Discussion of Members' Problems in the Application of Statistical Control.
April 15th	The Application of Statistical Control to the Quality of Blown Glass-ware—Mr. J. Elliott and Mr. W. J. Jennett.
May 7th	The Use of Statistical Methods in Steel Production—Mr. Glenn Wortley.

Tees-side Sub-Group

1946	
October 28th	Quality Control in Weighing and Filling Operations—Mr. J. S. Blackburn and Mr. L. Stabler.
1947	
January 9th	Introducing Quality Control in a Factory—Dr. B. P. Dudding.
February 13th	Some Fundamentals of Industrial Statistics—Mr. M. Milbourn.
April 10th	The Use of Statistics in the Solution of Steelworks Problems—Mr. N. H. Bacon.
May 15th	Statistical Control of Manufacturing Costs—Mr. W. L. Stevens and Mr. J. T. Richardson.

The Study Section

In 1945 the Council appointed a Committee to consider the revival of the Study Group of the Society, which was established in 1928 but had been in abeyance during the war. There was a large and favourable response to an enquiry sent to Fellows concerning their interest in the proposal, and the Council therefore decided unanimously to revive the Group under the title of the Study Section. A second letter was sent to interested Fellows, asking on what general subjects they would like to hear papers read and discussed. Arising out of these preliminaries the activities of the Section have been successfully revived.

Miss Iris Douglas was elected Chairman and Mr. H. Palca the Honorary Secretary of the Section Committee, and the other members of the Committee for the session were: Mr. R. F. George, Mr. M. G. Kendall, Miss J. Marley, Mr. D. Newman, Mr. G. R. White and Mr. J. R. Womersley.

Eight meetings have been held, at the first of which, on October 23rd, 1946, the general aims

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and objects of the Section—the study and informal discussion of statistical subjects—were considered by the members. Following on the second meeting of the session a Study Circle was set up to conduct research on the economic criteria for the stratification of social and economic surveys. At the last meeting Mr. L. T. Wilkins read a summary of the work of this Circle, and there was also a general discussion on the work of the Session and suggestions for the future.

Details of the eight meetings, each well attended and giving rise to keen discussion, were as follows:—

1946	
October 23rd .	Inaugural Meeting.
November 28th .	Dr. E. R. Bransby. Nutritional Surveys.
December 17th .	Mr. Ian Bowen. Building Statistics.
1947	
January 29th . .	Prof. R. A. Fisher. The Computational Aspect of a system of Scoring for Linkage, etc.
February 28th .	Mr. A. M. de Neuman. An Economist's Observations on Coal Consumption in Industry.
April 1st . .	Mr. and Mrs. A. P. Zentler. Statistical Aspects of Market Research.
May 14th . .	Dr. D. V. Glass. Population Surveys.
June 5th . .	Study Circle Report and General Meeting.

Frances Wood Memorial Prize

In 1946 the Council once more offered the Frances Wood Memorial Prize, value £30. Six entries were received. In view of the fact that the competition for this prize had been in abeyance throughout the war, and taking into account the standard of two of the papers submitted, the Council decided to make two awards. The successful candidates and the subjects upon which their essays were written were :—

Miss JOAN MARLEY .	A Statistical Survey of Certain Aspects of the Beef Production, Dairying and Cattle Rearing Industries in Great Britain between 1919 and 1947.
Dr. T. BARNA . .	Britain's Manpower Problem in the next Five Years.

At the invitation of the Council Miss Marley presented a shorter version of her essay to the Ordinary General Meeting held in April, 1947.

The Teaching of Statistics

In view of the growing recognition of the importance of statistics in government, commerce and industry, scientific research, and other fields, the Council decided in 1944 to appoint a Committee to survey the whole question of the teaching of statistics. This Committee, under the Chairmanship of Professor E. S. Pearson, has done much valuable work on behalf of the Society and has, during the year, presented a report to the Council on the teaching of statistics in universities and university colleges. This report, as adopted by the Council, will be published in the *Journal*, and will also, at an earlier date, be on sale as a reprint at a nominal price. Copies are being sent to university institutions in this country and the Dominions in the hope that it will assist them considerably in their plans for the development of the teaching of statistics. The Report stresses not only the present need for an increase in the number of professional statisticians but, very strongly, the importance of providing for *all* students of the social and natural sciences a training in statistical ideas and in elementary methods of statistical analysis. It points out that while the statistical approach, bearing to-day as much upon the affairs of everyday life as upon the scientific field of observation and experiment, may ultimately be introduced in schools, at present it falls upon the universities to provide such an outlook. To provide adequately for this general teaching and also to increase the supply of fully qualified statisticians, a fundamental need will be for more schools of statistics to carry on both pure statistical teaching and research. In statistics, as in other subjects, the Report points out, a profession of general practitioners requires the support of a nucleus of specialists, research workers and teachers. In short, the Report calls for the development of three main types of courses of instruction: (*a*) a general course to familiarize all students of the social and natural sciences with statistical ideas and simple methods, (*b*) a more advanced course to enable students properly to utilize statistical methods in

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their chosen science, a course which should be taken by most students of the social and biological sciences as part of the curriculum for a first degree, and (*c*) advanced courses for students of mathematical bent and for post-graduate training in both theory and practical applications. The Report also emphasizes the demand for extra-mural courses for graduates and others already in employment. Throughout all teaching it lays great stress upon the arithmetical basis of the subject and the importance, therefore, of practical work as a fundamental part of every course of instruction.

The Society's Examinations

Arising out of the new Bye-law No. 38, empowering the Council to hold examinations "for the purpose of testing the statistical proficiency of such Fellows as may desire to submit themselves," the Council, in November, 1946, appointed an Examinations Committee to prepare specific proposals. The Committee has considered examinations at two levels, for a Certificate at a lower level and for a Diploma at a higher. It has presented a report on the former, and will later deal with the more difficult matter of planning in detail an examination for the latter. For the Certificate examination the Committee has drafted regulations, after a careful study of the corresponding rules for several other existing examinations, and has drawn up a syllabus and specimen examination papers for the guidance of candidates. It has recommended that such examinations be held, in London only in the first instance, in December 1947, September 1948, April 1949, and thereafter annually in April. Its report, after some amendments on points of detail, has been adopted by the Council and sent to all Fellows with a request that any who propose to submit themselves for examination in 1947, 1948 or 1949 will notify the Assistant Secretary of the Society. The Council is much indebted to this Committee, and particularly to its Chairman, Mr. Kendall, for the large amount of work it has done on behalf of the Society in placing this examination system on a sound basis. The Council has now appointed a permanent Examinations Committee to make the necessary arrangements for the December 1947 Certificate Examination and to prepare a report on the proposed Diploma Examination.

The Journal

In its last Annual Report the Council pointed out that in the attempt to overcome the delay in the issue of the *Journal* it had authorized the Honorary Editors to issue, as a temporary expedient, two parts in one. That procedure in the latter half of 1944 and in 1945 did, in fact, considerably ease the situation. Owing, however, to the subsequent lack of paper, due to the coal shortage, and to general difficulties in printing, much of the ground then gained has unfortunately once more been lost. The Council is doing all it can to hasten the issue of the outstanding parts, but really effective action at present is impossible for reasons obviously outside its control. The provision of reprints of papers in adequate numbers is equally impossible.

The *Supplement* for 1946 (Vol. VIII, Parts I and II) has been published, these numbers being the first issues in the larger form, one which has clearly much advantage over the previous size. As with the *Journal*, the 1947 volume has been seriously delayed.

In 1946 Messrs. Richard Clay & Co. regretfully resigned their position as printers to the Society, for whom they had acted for twenty years. After inviting and considering tenders the Council appointed Messrs. Adlard & Son, Ltd., of Dorking, as Messrs. Clay's successors.

The Library

During the calendar year 1946 the services given to Fellows, and others authorized from time to time to use the Library, have considerably increased, as the following statistics show, the figures in brackets being the corresponding values for the previous year. 399 (284) Fellows, or approximately 25 per cent. of the total number, borrowed books. These Fellows made by post or in person 1,587 (1,204) effective applications, i.e. their requests to borrow a book or books could be met, and they borrowed 2,939 (2,458) volumes. The number of visits to the Reading Room, for use and study of books and material on the spot, numbered 1,953 (2,004), as measured

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by the signatures in the Register. Non-serial works added to the Library during the year amounted to 454 (363) volumes.

In making such additions to the Library and improving its value in other respects to Fellows, the Library Committee of the Council has been assisted by proposals put forward by Fellows by post and in the Suggestions Book. The latter medium of expression is in particular fulfilling a useful purpose and the attention of Fellows is drawn to it.

The International Statistical Institute

The activities of the I.S.I. have always been a matter of close interest to the Society. The Institute was organized in its present form at the Jubilee meeting of the Society in 1885. It met in London in 1905 and again in 1934, during the Centenary celebrations of the Society. Its last meeting was in Prague, on September 12th, 1938, but owing to the Munich crisis, was hurriedly closed on the following day.

The twenty-fifth session of the I.S.I. has been now convened in Washington for September 6th–13th, 1947, under the auspices of the American Statistical Association, and the President of the United States of America has consented to become its Honorary Chairman. At the same time there will be held meetings of the Inter-American Statistical Institute, the Econometric Society, an International Income Conference and, finally, a World Statistical Congress sponsored by the Economic and Social Council of the United Nations. These meetings will provide a unique opportunity for the meeting of statisticians in many different fields of work from all parts of the world.

As one of the main tasks of the I.S.I. will be its reorganization and re-orientation in the light of changed circumstances, the Council appointed a Committee, under the chairmanship of Professor Greenwood, to gather information. This Committee made a careful examination of an American draft of proposed new Statutes of the Institute and put forward a considerable number of suggestions, which have been sent to the Bureau of the Institute. The Committee also recommended that Mr. M. G. Kendall should be appointed the Society's representative at the Washington meeting, and the Council is glad to report that Mr. Kendall has agreed to attend on the behalf of the Society.

Finance

The abstracts of the Hon. Treasurer's Accounts, viz. the Statement of Income and Expenditure for the year 1946 and the Balance Sheet as at December 31st, 1946, together with the report of the Auditor thereon, are given in Appendices B and C.

Income other than Life Composition Fees increased from £3,819 in 1945 to £5,344 in 1946. There were increases of £440 in Fellowship subscriptions, of £152 in Industrial Applications Section subscriptions, of £870 in *Journal and Supplement* sales and of £60 in Dividends and Interest. Owing to increased activity in all branches of the Society's work Expenditure increased at a somewhat greater rate, from £3,300 to £5,205 ; the main increases were £120 in Salaries and Wages, £200 in Pension and Allowance, £177 in Expenses of Sections, £564 in *Journal* Expenses, £481 owing to the resumption of the publication of the *Supplement*, and £141 in Stationery and Miscellaneous Printing. The Excess of Income over Expenditure transferred to the Accumulated Fund of the Society was £139 in 1946 as compared with £519 in 1945.

Composition Fees, which have been steadily increasing in recent years, amounted to £1,041, and were as usual transferred to the Life Composition Fee Fund. In addition it was thought desirable to bring this Fund up to the total of the Composition Fees paid by all Fellows living at the end of the year, £5,818, by the transfer of £1,108 from the Accumulated Fund of the Society. The new scale of Composition Fees, based on age and length of Fellowship puts such payments on a more equitable basis.

During 1946 the sale of £1,170 3 per cent. Local Loans showed a profit of £366, which was transferred to the Accumulated Fund. £2,000 3 per cent. Defence Bonds were purchased. After making the transfers already referred to, the Accumulated Fund of the Society amounted to £7,654 at the end of 1946.

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The Council and Officers

Acting under the revised Bye-laws the Council in December, 1946, invited all Fellows to make suggestions for the composition of the ensuing Council. Taking carefully into account the suggestions received it then circulated its recommendations as set out below. As no alternative nominations have been received these Fellows will be announced at the Annual General Meeting to be held on July 10th, 1947, as having been elected as the President, Officers and other members of Council for the session 1947–48.

In conclusion, the Council wishes to express, on its own behalf and on behalf of the general body of Fellows, its very real gratitude to the retiring President, Lord Woolton, for the time, energy, wisdom and—not least—good humour and sense of proportion that he has devoted to the Society's affairs. It is glad to announce that as one of the three most recent Presidents continuing their Fellowship he has consented to continue a member of the Council. The two other past Presidents who have agreed to serve on the Council are Dr. E. C. Snow and Mr. H. Leak. In welcoming Dr. Heron as the new President the Council takes the opportunity of acknowledging in its Report, and on behalf of all Fellows, the most valuable services he has given to the Society as Honorary Treasurer, in the management of its finances over the last eight years.

President

Dr. David Heron.

Council

R. G. D. Allen.
M. S. Bartlett.
*H. Campion.
Sir Alexander Carr-Saunders.
†D. G. Champernowne.
H. E. Daniels.
†D. J. Desmond.
*Iris Douglas.
D. J. Finney.
C. Oswald George.
R. F. George.
Sir Gwilym Gibbon.
R. Glenday.
M. Greenwood.
A. Bradford Hill.
J. O. Irwin.
W. J. Jennett.
J. H. Jones.
M. G. Kendall.
†Philip Lyle.
G. H. Maddex.
*E. S. Pearson.
E. C. Rhodes.
†H. L. Seal.
R. Stone.
B. L. Welch.
G. R. White.
J. Wishart.
J. Womersley.
F. Yates.

Honorary Treasurer

J. H. Jones.

Honorary Secretaries

A. Bradford Hill. C. Oswald George. M. G. Kendall.

Honorary Foreign Secretary

A. Bradford Hill.

On behalf of the Council,
WOOLTON,
President.

A. BRADFORD HILL
C. OSWALD GEORGE
M. G. KENDALL
} *Honorary Secretaries.*

June, 1947.

Those marked * were not Members of Council during the preceding session and those marked † have never previously served on the Council.

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Appendix A

From June 1946 to May 1947, inclusive, the candidates named below were elected Fellows of the Society:—

Adler, Max, Dr. rer.pol.
Al-Khedairy, Ibrahim.
Armstrong, William Cecil.
de Artigas, Jose Antonio, Professor.
Athol, Robert Charles.
Bain, John C., B.A.
Bamforth, Frank.
Barley, Ronald Gordon.
Barnard, George Alfred, M.A.
Barnett, Benjamin, B.A.
Bell, Lloyd Elgar.
Beynon, P., B.A.
Bhat, Manjeshwar Dayananda, M.A.
Birbeck, Harold Leslie.
Boag, John William.
Bowers, Charles Henry.
Bowes, Edgar Ashcroft, B.Sc.
Box, George Edward Pelham.
Brook, Leslie Norman.
Browne, Kevin.
Caldwell, Harold Ernest, M.B.E., F.C.C.S., M.I.B.
Carrier, Norman Henry.
Carter, Alan Herbert.
Cashen, Rose Olga, B.Com., Ph.D.
Caston, George Stephen Huntingdon.
Chester, John.
Churches, Albert Edward Owen, B.Com.
Clark, Kenneth John.
Clarke, Samuel Harrison.
Clinch, Charles Ernest Everard.
Cockfield, Francis Arthur, LL.B., B.Sc.
Coglan, William Nicholls, B.Com.
Cooper, Reginald Harry, M.A.
Cottrell, Walter James.
Cousins, Wilfred Rodney.
Cox, David Roxbee.
Cox, Donovan.
Cox, George Harold.
Cramp, Stanley, B.A.
Cullen, Francis Peter.
Cullen, Walter, Capt., E.M.E.
Cuthbertson, Jack Rushbrooke, B.A., A.C.A.
Dacey, W. Manning.
Darbyshire, Bernard Norman, B.A.
Davy, Edwin.
Dawson, Eric.
Day, Joseph Gilfrid.
Deming, W. Edwards.
Denton, Arthur Denis.
Desbrow, Laurence Walter.
Dewey, Alfred Arnold.
Dhume, S. M., Ph.D.
Diananda, Palahendi Hewage.
Dibben, Sidney Gilbert.
Din, M. Ziaud, M.A., Ph.D.
Dinsdale, Walter Arnold, B.Com.
Dorizzi, Stuart Dixon, B.Sc.
Drukker, Margaret Louise.
Duncan, George Milton, Lieut.-Cdr., R.N., O.B.E.
Dunkerley, Harold Beddows.
Dyer, Philip Frederick.
Easterfield, Thomas Edward, M.Sc., Ph.D.
Edney, George, B.Com.
Ellefsen, Olaf Leonard Erik.
Emery, Charles Walter.
Eslick, Kenneth Leslie.
Farrell, Michael James.
Fell, Harry.
Felthouse, William Ernest.
Fereday, Felix, M.Sc.
Fitzpayne, Eric Richard Leman, B.Sc.
Forster, Charles Ian Kennerley, F.I.A.
Freud, Joseph.
Gangolli, Vasant D.
Gibson, Evelyn Helena, B.A.
Gilbey, Bernard Edlin.
Giles, Evelyn Maude, B.Sc.
Glassborow, Peter Waters.
Grant, Francis, Major.
Gray, Percy George.
Gray, Robert Walker.
Greaves, Mary Elsworth.
Griffith, John.
Hake, Henry Albert.
Haller, Bertram.
Hancock, William Keith, Professor.
Heady, James Austin.
Hill, Norman Douglas, B.Sc.
Hopkins, Melville Rees, M.Sc.
Hudson, Harold Gaunt.
Hughes, Roland, B.Sc.
Hunt, Eileen Audrey, B.Sc.
Huppert, Eric L., Ph.D.
Hurtado, Cristobal.
Ives, Philip Lionel.
Iyengar, S. Ramaswamy, M.Sc.
Iyer, Trivandrum Sunramania Seetharama, M.A., B.Com.
Jenkins, John Harold, B.Com.
Jennings, Denys Arthur, M.A., B.M., B.Ch., D.M.R.E.
Johnson, Daniel Emanuel Ojumiri.
Johri, Tej Bahadur, M.Com.
Jones, Daniel Thomas.
Jones, Walter John, M.Sc.
Kadhim, Sayyid Hamid.
Kamath, Vasudeva Bantwal, M.Sc.
Kavanagh, Michael Thomas, A.R.C.S., B.Sc.
Keen, Joan Ethel, B.Sc.
Kelly, Brendan Kevin, B.A.
Kenney, Herbert James.
Khamis, Salem Hanna.
Kidman, Charles Hugh.
Knight, Ella, M.A.
Koop, John Clement.
Kubba, Saleh Abdul Amir, B.A.
Kupperman, Morton, B.Sc.
Lacey, Kenneth.
Lansley, Arthur William.
Leary, John Edward.
Lewis, Everett Vernon, S.B., Ph.D.
Liddington, Herbert John, B.Sc.
Linnell, M. E., M.A.
Lloyd, Emlyn Howard, B.Sc., A.R.C.S., Ph.D.
Lloyd, Eynor, M.A.
Locke, Donald Erskine.
Longley-Cook, Laurence Herbert, M.A., F.I.A.
MacColl, Alistair Bruce.

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McCormick, Henry.
McKelvie, David Gardner.
McLellan, Horace William.
Maclean, John.
Manning, John Rowland.
Marshall, Arthur Hedley.
Mayer, Alexander Winand John.
Milbourn, Maurice.
Milnes, Alfred Hallett.
Mitchell, Tom Edward, B.Com.
Monkhouse, Francis John.
Moore, John Arthur.
Morley, John.
Moroney, Michael Joseph.
Moss, Michael Philip.
Mould, Leonard Pearce.
Murphy, Donald Cyril, M.A.
Murray, John, M.A., Ph.D.
Nair, A. N. Krishnan.
Nathan, Charles Henry.
Neurdenburg, M. G., M.D., D.P.H.
Orr, Charles William Pache, LL.B.
Oswin, Charles Robert.
Park, Alexander Thomson, M.A.
Parkinson, John Richard.
Patnaik, Pakki Bhaktavatsal, M.A.
Patterson, Henry Desmond.
Percival, Arthur Thomas.
Perryman, James Henry.
Pillai, P. S. Bhaskaran.
Polman, Maurice Charles, F.I.A., A.A.S.
Porteous, Douglas Archibald, F.F.A.
Ramsay, James Macnab.
Read, Dennis Rouse.
Richards, John Desmond, B.Com.
Roach, Alphonso D.
Robinson, Edward Austin Gossage, M.A.
Robinson, John Douglas, A.I.A.
Robinson, Neville Whiteoak.
Rodgers, John Wentworth.
Rodrigues, Milton Camargo da Silva, Professor.
Rogers, Aeron C., M.A., B.Sc.
Ross, Alfred William, M.A.
Sampford, Michael Robert, B.Sc., A.R.C.S.
Saville, Frederick Aubrey.
Scarborough, Charles Patten, B.Sc.
Scheuer, Rose, B.Sc.
Schiller, Kurt, Ph.D.
Seddon, James Hateley, Major.
Shave, Alan Edward.
Shepley, Harold Hartley.
Singh, Mohinder, M.A., Ph.D.
Sleptzow, Valerian.
Smith, Alan Buchanan Carrick, M.A.
Smith, Arthur George Ernest, B.Sc.
Smith, Kenneth, B.Com., M.Sc.
Smith, Kenneth Vernon, B.Sc.
Smith, Raymond Stanley.
Spink, James Francis, Litt.D., Th.D., Ph.D.
Stalbow, Richard Benson, B.Sc.
Stanton, Hugh Cyril.
Steylaerts, Roger Jean Gustave.
Stoneman, John Leonard Spencer, M.A.
Tasker, Reginald Frank.
Taylor, René Claude, B.A.
Thayre, Albert Jesse, M.B.E.
Thomas, Francis Herbert, M.B.E.
Thomas, Herbert Arthur.
Thomas, Terence Edward Haydn.
Tocher, Keith Douglas, B.Sc.
Tovey, Douglas Hammond, B.Sc.
Turl, H. W., Lt.-Col., B.A., B.Sc.
Vaswani, Khushiram Nehhraj, Professor.
Wallace, Harold Charles, F./Lt.
Walmsley, Charles Cockerill.
Walter, Heinrich, Dr. jur.
Wansbrough, George.
Watson-Hyett, Ronald William, Major, B.A.
Weinberg, B. Abraham.
Welch, George.
Weller, Owen George.
Wheeler, Kenneth Alfred Coe, F.I.A.
Whiting, Arthur Noel.
Whitwell, John Lawrence.
Willatt, Arthur Stanley.
Williams, Gwylmor Prys.
Willsmore, Albert William.
Willson, Joan Mary, M.A.
Wilson, William Arthur.
Woodgate, Donald Richard, M.Com., F.I.A.
Wootton, Alan Frederick.
Worrall, Ralph Lyndal.
Young, Terence Charles John.

Corporate Representatives

Beales, Reginald Edwin, F.I.A., *representing* The Central Statistical Office.
Beek, Eileen Mary, *representing* Guthrie & Co., Ltd.
Chappell, Alan Kingsley, *representing* McCann-Erickson Advertising, Ltd.
Craster, Sir Edmund, *representing* All Souls' College, Oxford.
Deane, Marjorie, *representing* *The Economist* Newspaper.
Jennings, Albert, *representing* Murphy Radio, Ltd.
Jones, Leslie Charles, *representing* Associated British Oil Engines, Ltd., and British Oil Engines (E), Ltd.
Lambert, Fred, B.A. *representing* Market Research Dept., Co-operative Wholesale Society, Ltd.
Lynton, Rolf Peter, B.Sc. *representing* Leathley Publications.
McMullen, Launce, *representing* Arthur Guinness, Son & Co., Ltd.
Morrow, Ian Thomas, *representing* Robson Morrow & Co.
Rees, Edmund, J., F.L.A. *representing* Cardiff Public Libraries.
Smith, Trevor John, *representing* de Zoete & Gorton.
Sraffa, Piero, *representing* The Marshall Library of Economics.
Walford, Albert John, M.A., Ph. F.L.A., *representing* The Joint Intelligence Bureau (Office of the Minister of Defence).
Wormald, Avison, *representing* British Nylon Spinners, Ltd.

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APPEN

STATEMENT OF INCOME AND EXPENDITURE

EXPENDITURE.

1945.						1946.					
£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.
			380	*0*	*0*	Rent				380	0	0
			231	*15*	*6*	House Expenses				304	8	1
			1,164	*0*	*5*	Salaries and Wages (including contribution to Staff Superannuation Scheme)				1,284	8	2
			39	*0*	*0*	Pension and Allowance				239	0	0
			161	*2*	*3*	Meetings—Ordinary and General				198	4	2
						Expenses of Sections:—						
8	*2*	*6*				Research	57	12	1			
34	*1*	*1*				Industrial Applications	148	10	2			
—	—	—				Study	13	3	7			
			42	*3*	*7*					219	5	10
						Publication and Distribution Expenses:—						
791	*0*	*10*				Journal and Reprints	1,354	19	2			
—	—	—				Supplement	480	14	3			
			791	*0*	*10*					1,835	13	5
						Library:—						
102	*9*	*5*				Books	90	11	11			
17	*19*	*0*				Binding	14	18	0			
			120	*8*	*5*					105	9	11
			20	*16*	*1*	Insurance				23	6	4
			150	*12*	*4*	Stationery and Miscellaneous Printing				291	5	9
			80	*19*	*4*	Postage and Telephone				121	8	1
			42	*3*	*11*	Guy Medals				36	3	4
			2	*14*	*5*	Miscellaneous Items				16	8	5
			36	*15*	*0*	Auditor's Fee [1945]				36	15	0
			4	*9*	*4*	War Damage Insurance				—	—	—
			31	*10*	*0*	Emergency Transport and Storage				5	10	0
			—	—	—	Office Equipment				46	4	8
						Legal Expenses in respect of Petition for Supplemental Charter and revision of Bye-laws				61	8	0
			3,299	*11*	*5*					5,204	19	2
			519	*4*	*8*	Balance carried to Accumulated Fund: Excess of Income over Expenditure for the year 1946				138	19	9
			3,818	*16*	*1*					5,343	18	11
			766	*10*	*0*	Amount carried to Life Composition Fee Fund				1,040	11	0
			£4,585	*6*	*1*					£6,384	9	11

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DIX B

FOR THE YEAR ENDED 31ST DECEMBER, 1946

INCOME.

1945. £ s. d.	£ s. d.		1946. £ s. d.	£ s. d.
		Annual Subscriptions:—		
2,265 18 0		Fellowship	2,705 17 0	
— — —		Research Section	1 10 0	
— — —		Industrial Applications Section	151 10 6	
	2,265 18 0			2,858 17 6
	948 14 2	Sales of Journal and Reprints		1,710 13 10
	3 0 0	Journal Advertisements		— — —
	68 16 5	Sales of Supplement		177 2 6
	1 16 0	Sales of other Publications		13 9
	50 0 0	Contribution from Royal Economic Society		50 0 0
	480 11 6	Dividends and Interest (gross)		540 11 7
	— — —	Special Donations to Library		3 13 6
	— — —	Miscellaneous Receipts		2 6 3
	3,818 16 1			5,343 18 11
	766 10 0	Life Composition Fees		1,040 11 0
	4,585 6 1			£6,384 9 11

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APPEN

BALANCE SHEET AT

LIABILITIES.

1945. £ s. d.	£ s. d.		1946. £ s. d.	£ s. d.
		Annual Subscriptions received in advance:—		
117 12 0		Fellowship	124 19 0	
10 0		Research Section	— — —	
99 10 0		Industrial Applications Section	— — —	
— — —		Study Section	10 0	
	217 12 0			125 9 0
	509 0 10	Payments for Journal and Supplement received in advance		915 2 1
	251 9 0	Sundry Creditors		733 1 10
		Life Composition Fee Fund:—		
2,903 5 0		Balance at December 31st, 1945	3,669 15 0	
766 10 0		*Add:* Life Composition Fees received in 1946	1,040 11 0	
		Amount required to increase Fund to total of Composition Fees received from Fellows still living at December 31st, 1946, transferred from Accumulated Fund	1,107 15 0	
— — —				
	3,669 15 0			5,818 1 0
		Accumulated Fund of the Society:—		
7,737 15 11		Balance at December 31st, 1945, per last Accounts	8,257 0 7	
		Add: Excess of Income over Expenditure for the year 1946 per annexed Statement	138 19 9	
519 4 8		Profit on realization of Investment ..	366 1 5	
— — —			8,762 1 9	
		Less: Amount transferred to Life Composition Fee Fund	1,107 15 0	
— — —				
	8,257 0 7			7,654 6 9
	12,904 17 5			15,246 0 8
		Building Fund (per contra):—		
1,066 19 7		Balance at December 31st, 1945 ..	1,107 9 6	
40 9 11		*Add:* Income for year 1946	41 16 7	
	1,107 9 6			1,149 6 1
		Frances Wood Memorial Fund (per contra):—		
483 2 11		Balance at December 31st, 1945 ..	511 16 8	
28 13 9		*Add:* Income for year 1946	29 19 5	
	511 16 8			541 16 1
	£14,524 3 7			£16,937 2 10

Note.—No value is placed in the Accounts on (1) Journals and other Publications in stock, (2) Books in Library, and (3) Pictures, Furniture and Equipment.

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DIX C

31ST DECEMBER, 1946

ASSETS.

1945. £ s. d.	1945. £ s. d.		1946. £ s. d.	1946. £ s. d.
		Investments at cost or under:—		
		£10,527 12*s.* 3*d.* 2½% Consols (Guy Bequest)	5,580 0 0	
5,580 0 0		£2,236 11*s.* 3*d.* 2½% Consols	1,185 0 0	
1,185 0 0		£1,864 14*s.* 1*d.* 3½% Conversion Loan	1,324 0 0	
1,324 0 0		£500 3½% War Loan	490 0 0	
490 0 0		£1,169 17*s.* 6*d.* 3% Local Loans Stock	— — —	
800 0 0		£2,000 3% Savings Bonds, 1965–75	2,000 0 0	
2,000 0 0		£2,000 3% Defence Bonds	2,000 0 0	
— — —		£666 4% 2nd Prefd. Stock, London and North-Eastern Railway	100 0 0	
100 0 0				12,679 0 0
	11,479 0 0	(Market value, December 31st, 1946, less Interest accrued, £19,603)		
	117 3 10	Interest accrued on Investments (gross)		141 6 7
	1,011 7 6	Cash at Banks and in hand		1,912 4 3
	84 0 0	Arrears of Subscriptions recoverable (estimated)		84 0 0
	188 14 11	Sundry Debtors and amounts paid in advance		429 9 10
	24 11 2	Stock of Journal Paper		— — —
	12,904 17 5			15,246 0 8
		Building Fund:—		
		£1,223 8*s.* 5*d.* 3½% Conversion Loan (Market value, December 31st, 1946, £1,406)		
	1,107 9 6			1,149 6 1
		Frances Wood Memorial Fund:—		
		£600 4% Preference Stock, London, Midland and Scottish Railway	300 0 0	
300 0 0		(Market value, December 31st, 1946, £501)		
199 16 8		Post Office Savings Bank Deposit	229 16 1	
12 0 0		Income Tax Refund due	12 0 0	
	511 16 8			541 16 1
	£14,524 3 7			£16,937 2 10

REPORT OF THE AUDITOR.

I have examined the foregoing Statement of Income and Expenditure and Balance Sheet with the Books and Records of the Society. I have verified the Investments and Cash appearing in the Balance Sheet. I report that the above Balance Sheet is, in my opinion, properly drawn up so as to exhibit a true and correct view of the state of the affairs of the Society, according to the best of my information and the explanations given to me, and as shown by the Books and Records.

A. RAE SMITH, *Chartered Accountant*, Auditor.

9th May, 1947.

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PROCEEDINGS OF THE ONE HUNDRED AND THIRTEENTH ANNUAL GENERAL MEETING OF THE ROYAL STATISTICAL SOCIETY, HELD AT THE LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE ON THURSDAY, JULY 10TH, 1947, AT 5.15 P.M.

The Chair was taken by the PRESIDENT, the RT. HON. LORD WOOLTON, P.C., C.H.

The PRESIDENT announced that as no alternative nominations had been received, the President, Council and Officers for the session 1947–48, nominated as shown on the list already circulated, were duly elected.

The HONORARY TREASURER, Dr. David Heron, proposed that Sir Alan Rae Smith be re-elected Auditor of the Society for the session 1947–48 at a fee of thirty-five guineas.

Professor J. H. Jones seconded the motion, which was carried unanimously.

The PRESIDENT presented the Report of the Council for the financial year 1946 and the session 1946–47. He referred to the steadily growing activities of the Society and its various Sections, and to the large increase in the Fellowship. He called attention to the work of the Committee on the Teaching of Statistics, whose report, adopted by the Council, would be published in the *Journal*, Part I, 1947, and to the work of the Examinations Committee, whose report the Council had already sent to all Fellows and which would appear in the same issue of the *Journal*.

During his submission of the Report the PRESIDENT presented Frances Wood Memorial Prizes to Miss Joan Marley and Dr. T. Barna.

The PRESIDENT moved the adoption of the Report.

The HONORARY TREASURER presented the accounts and seconded the motion for the adoption of the Report.

Mr. F. A. A. Menzler, Mr. M. G. Kendall and Mr. W. R. Buckland spoke on the Society's proposals for the Certificate examination, and it was agreed that an ordinary general meeting in a subsequent session be devoted to a discussion on the teaching of statistics.

The Report was unanimously adopted.

The Meeting then terminated.

REPORTS FROM COUNCIL AND NOTICES TO FELLOWS

In a previous issue of the *Journal* (1946, Part II) the Council drew the attention of Fellows to the fact that from time to time requests are received from employers for the names of statisticians who wish to be considered for vacancies or new posts of a statistical character. To help in putting prospective employers and employees in touch the Council arranged that the Assistant Secretary would keep a list—

(*a*) of Fellows who indicate their interest in obtaining statistical posts; and
(*b*) of posts which are notified to the Council by employers as being vacant.

The Council would remind Fellows of this arrangement. Those who wish to be put on the list should write to the Assistant Secretary giving particulars of age, education, qualifications, experience and present employment, and should also specify which types of statistical work they are interested in. Employers who have vacant posts to be included on list (*b*) should similarly communicate with the Assistant Secretary specifying their requirements. Particulars of these vacant posts will then be circulated to such Fellows on list (*a*) as would appear to be interested in the type of work so that they can themselves make contact with the prospective employer. Names of Fellows seeking posts will not be given directly to any employer. Fellows on the list who obtain employment should, of course, inform the Assistant Secretary so that their names may be removed. The Council also hopes that Fellows will whenever possible bring this arrangement to the notice of employers.

The Council has been considering various aspects of the Society's two publications, the Journal and the Supplement to the Journal. In particular it has agreed that the latter title is by no means appropriate to an issue that, both in quality and quantity, is itself a scientific journal of high repute. The word "supplement" may indeed be misleading to those who are unaware of its content. The Council has, therefore, decided that in future its two publications will *both* be issued as the Journal of the Royal Statistical Society, the original Journal being distinguished by the sub-title "Series A (General)" and the Supplement by the sub-title "Series B (Methodological)." The volume numbers will in both cases continue as at present.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

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1.—*Selected Techniques of Statistical Analysis for Scientific and Industrial Research and Production and Management Engineering*. By the Statistical Research Group, Columbia University. McGraw-Hill Book Company, 1947. 9″ × 6″. xv + 473 pp.

During the last war the Statistical Research Group of Columbia University carried out work for the Applied Mathematics Panel, which administered contracts of the Office of Scientific Research and Development, the vast organization set up in the United States to utilize the scientific man-power of the country. The scope of the Panel included "Probability and Statistical Studies," and American statisticians have indeed proved that they were equal to their task. The staff of the Columbia group was drawn from universities and research organizations throughout the country, and included some of the foremost exponents of statistical theory. Naturally its work was mainly concerned with problems arising directly out of the war, but it is a pleasure to find that, as in Great Britain, statisticians of a more theoretical frame of mind were encouraged to make their contributions by developing theories incidental to their main duty of assisting the Army, the Navy and the OSRD in the statistical aspects of their problems.

At the end of the war the group disbanded and it was felt that their results should be made available to a wider public. Some of the reports are still "classified," and thus only allowed to be communicated in confidential documents. Others have been published in book form or in papers, mainly in the *Annals of Mathematical Statistics*. Into this category belongs Sequential Analysis, which A. Wald developed as a member of the group. There remained work of, perhaps, less importance, which the group did not wish to be buried in inaccessible files and a collection of it is here presented as a book. This is probably a fair way of letting all members of the group have their share in deserved publicity, but it is responsible for a presentation much less even than one might wish for.

Under the editorship of C. Eisenhart, M. W. Hastay and W. A. Wallis a number of authors have contributed. Among 17 chapters there is one of 87 pages (Ch. 1: Use of Variables in Acceptance Inspection for per cent. Defective, by W. A. Wallis) and one of only 5 pages (Ch. 14: Probability that Sample Means are in Opposite Order to Population Means, by C. Eisenhart), the majority being of about 10 pages. The chapters are grouped in three Parts: I. Industrial Statistics; II. Planning Experiments; III. Techniques and Tables, and the reviewer must state that he did not find this subdivision of the subject matter very convincing. To give a few examples we mention in Part I, Ch. 3, Multivariate Quality Control, by H. Hotelling, and Ch. 4, Effects of Rounding or Grouping Data, by C. Eisenhart; in Part II, Ch. 8, Planning and Interpreting Experiments for omparing two Standard Deviations, by C. Eisenhart, which contains 28 pages of tables from which probabilities of errors of the second kind can be found; and Ch. 10, Experiments in which the independent variable is known only in terms of a probability distribution, by J. Wolfowitz; finally in Part III, Ch. 17, Elements of Sequential Analysis, by W. A. Wallis.

It is clear that the reader of such a book cannot focus his attention on any particular subject. He might still find it useful for reference, if it were easy to find the exposition of any idea contained in it, if one searched for it at some future time. But though the Index is extensive, it is hardly appropriate for this purpose. We fear that it is very difficult to appreciate the traces of new aspects and novel methods which are undoubtedly contained in the chapters, but are not made very noticeable. In fact, only readers very familiar with the problems treated will recognize where the author has either ingeniously used a related technique or has been successful in creating a new one, which might be useful in other circumstances as well. However, one ought not to stress too much one's regret at lost opportunities, since the book was produced at a time when all collaborators were already naturally looking for other work than recording what must have become, by then, old stories.

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It is a consequence of the happy co-operation between the U.S. and this country during the late war that credit is fairly given, where due, to British statisticians. This is very gratifying, and at the same time it adds some bitterness to the feeling that too little is being done in this country to make the statistical contributions to our war effort more appropriately known. S. V.

2.—*Industrial Statistics and Quality Control.* By Paul Peach. 2nd ed. Raleigh, N.C.: Edwards & Broughton, 1947. xv + 235 pp. 9″.

This book is based on a ten-day course on quality control given just after the end of the war in the U.S.A., and most of its short-comings can be attributed to this fact. It deals at some length with quality control and sampling inspection, but the rest of the extensive field of statistical methods in industry is dealt with only cursorily. The publication in this country of an American book inevitably leads to many comparisons between the practices current on either side of the Atlantic, and it should therefore be pointed out that many procedures recommended in this particular book will find very little sympathy with practitioners in this country.

Certain points in the presentation of the subject are worthy of commendation. An attempt is made to give an outline of the theory fundamental to the subject by discussing some elementary ideas of probability. The relation between populations and samples is also treated, and the brief sketch of some of the general ideas underlying the theory of testing hypotheses could be very profitably expanded, even in a book of this type. The book is not a theoretical treatise, but it does try to illustrate the relationship between theory and practice by considering such points as the cost of various statistical procedures from the view points of both buyers and sellers. The chapter on gauges contains much good practical advice, and the author fully realizes the various errors that occur in gauging, errors that are far from being widely recognized. The problem of measuring these errors is, however, treated too superficially to be of much practical guidance. The book also contains some novel methods, and in particular a graphical method of determining the significance of Student's t should prove very acceptable in factories, particularly to engineers addicted to the use of nomograms.

Such aspects of the book are perhaps of considerable help to the beginner, but there are some methods outlined which, although they may have proved useful in the U.S.A., are not generally accepted here. A new-comer to the subject, trying to apply these without proper understanding, would encounter many difficulties. This is particularly true of tables recommended for obtaining various types of sampling schemes. Some of these are not available in this country, while others are inferior in flexibility to tables and charts already published here.

The terminology of this book differs in many respects from British terminology. For instance, the term "control chart" is used to cover almost any chart plotted in the factory, whereas in this country the term is used only to designate charts used specifically for production control.

There are a number of techniques widely used in England of which the author seems completely unaware. Group control charts, which have proved quite useful here, are not mentioned, but instead, the method recommended for the joint control of a number of machines consists of pooling together the samples taken from each—a practice which most British authorities on the subject recommend for only very special cases.

Although the inclusion of the discussion of fundamental ideas is to be welcomed, in many respects it is far from adequate. Ideas of the location and spread of a distribution, independence of variables and bias are treated very loosely. The omission of a fuller discussion of the implication of the conception of significance is particularly grave, as the book includes what is intended to be a guide to experimental design. The Neyman-Pearson conception of power is introduced at one stage, but its practical implications are not developed to any extent. The author fails to see that by using this important idea the choice of the size of sample in control chart work need no longer be an arbitrary decision, and that further there may also be an advantage in using more than the one set of control limits (of unspecified significance) derivable from his Table VII.

By implication the author seems to favour natural control limits and deprecate modified control limits as an expedient to be used only when nothing better is available. This is an unrealistic approach to the problem, as there is no particular virtue in a product being in statistical control; all that is required is that it shall be produced within specification, and modified control limits ensure this. In any case the methods outlined for calculating modified control limits (there are no tables given) would be considered meaningless in this country, and no explanation is given of their theoretical basis.

In dealing with fraction-defective charts the author recommends using the Poisson approximation to the Binomial for probabilities as great as 0·2. There will be little approval of this here, as it is not usual to use this approximation for probabilities greater than 0·1.

The discussion of sampling inspection schemes is mainly sound, and lacks clarity only on some

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finer points. The distinction between the risks offered by a scheme and those experienced in practice and the relationship between average sample size and costs are two points which merit more elaborate treatment than they receive. One weakness of this section is that it fails to show how the various types of scheme arise from different practical situations, and how, in fact, with the necessary mathematical equipment it is possible to devise special schemes to meet special situations.

The latter part of the book attempts to give the reader a guide to the use of more advanced statistical methods in industry, and in the opinion of the reviewer fails completely. On the one hand the author considers that the discussion of correlation is outside the scope of his book, but on the other hand he attempts to outline some methods of experimental design and analysis. In opening the discussion of this subject, however, one feels that a more appropriate example than the pig-feeding experiment should have been available from industrial experience to illustrate some elementary ideas on design. Two pages are devoted to the Latin Square experiment, and these cover litle more than an outline of the computational procedure to be followed in analysing the experiment. In view of the many difficulties that can arise with this type of experiment in industry this treatment must surely be considered too superficial. This is also true of the author's treatment of the idea of the interaction of two factors—the understanding of which is of great importance in industrial experimentation—which he deals with in four lines. The inclusion of this wholly inadequate discussion of so vital a subject as experimental design can find little justification. The beginner in the application of statistical methods to industrial problems will get no benefit from it, while the more advanced student should be well enough equipped to read a more complete account of the theory elsewhere.

The book is, of course, intended only for the practical man in industry, and makes no claim to give the theoretical basis of statistics; but the theoretical short-comings of the book could lead the practical man into many serious practical errors. From the viewpoint of the industrialist it must be pointed out that the book has a strong bias towards light engineering, and deals very little with statistical problems arising in the chemical or other industries. Undoubtedly those concerned with applying statistics in industry will find some useful ideas in the book, and it is to be regretted that the author did not think them worthy of a proper index. D. N.

3.—*An Introduction to Managerial Business Statistics.* By Harry Pelle Hartkemeier. New York: Thomas Y Crowell, 1943. xiv + 207 pp. $10\frac{1}{2}''$. $2.00.

The title of this book is entirely misleading; in fact the author gives an elementary discussion of a few standard statistical tests, viz. the t-test for the difference between two arithmetic means, the F-test for comparing two standard deviations, the χ^2-test for contrasting frequency distributions, and a brief description of control charts for mean and standard deviation.

The text is preceded by an introduction in which generalities far beyond the actual scope of the work are discussed. The beginner is, therefore, given the impression that the above tests are capable of dealing with such weighty matters as Analysis of Time Series and Index Numbers and provide a complete tool for correlation problems—a definite case where some little learning may prove dangerous.

Although the introduction of the concept of variability is fairly lucid, the bulk of the text is an amazing jumble of quite elementary computing instructions expounded at length, alongside with philosophical discourses on the concept of a null hypothesis in tests of significance. A number of examples, all on commercial data, are worked in detail, numerous others are set as "problems," and half the booklet consists of preprinted computing forms on which students and "business statisticians" alike are supposed to do their homework!

Certain of the methods advocated are inefficient or faulty. To name two examples: In the computational instructions for forming the sample standard deviation the author first introduces the method of forming individual deviates from the mean, forming their squares and then adding them on an adding machine; later the original data are squared, but the possibility of forming the sum of squares directly on a calculator appears to be ignored, at least all the computing forms show a column for the individual X^2. In the control chart for the sample standard deviation the author computes control limits from $t \cdot s/\sqrt{2n}$ (n = sample size), which appears to be based on a fundamental misinterpretation of the t-distribution. H. O. H.

4.—*Cost of Living Statistics: Methods and Techniques for the Post War Period.* Report prepared for the Sixth Internatonial Conference of Labour Statisticians. London: Staples Press, Ltd. $9\frac{1}{4}'' \times 6\frac{1}{4}''$. iv + 56 pp. 1*s.* 6*d.*

The Sixth International Conference of Labour Statisticians was convened at Montreal in August, 1947, when one of the items on the agenda was "Cost of Living Statistics: Wartime and

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Post-war Developments in Methods and Techniques." The present Report on cost of living statistics was prepared by the International Labour Office as a paper for this item. The Report summarizes the discussion under three main headings—the purposes which may be served by different types of cost of living indices in the post-war period; techniques for obtaining and utilizing representative price data; weighting diagrams.

The Report early suggests that to clarify the concept of a cost of living index the term "cost of living" should be replaced by the term "retail price index" or "consumer prices index." After discussing the measurement over time in the retail prices of consumer goods, and at a given time between different places, the Report considers those groups of the population which should, if feasible, be covered by cost of living indices. It is suggested that besides wage earners, clerical workers and the farm population, special index numbers should be considered for other groups of workers such as salaried employees or officials (particularly European groups living in Asiatic countries) and perhaps teachers. The question then arises of providing a comprehensive index for the whole population.

The problems associated with the collection of representative price data are briefly discussed, with emphasis on the careful selection and training of the persons responsible for collecting the data. There is an interesting section devoted to black market prices, in which the criteria suggested for their inclusion are first whether black market prices are an important element in the cost of living, and secondly whether they can be accurately measured.

The conclusion reached with regard to weighting is that items not priced should be taken into consideration, so that "all items purchased by the group covered can be represented in the index, though not all are priced." The Report briefly describes the methods practised in various countries for dealing with seasonal items, e.g. fresh fruits, clothing and fuel, and in the following section emphasis is laid on the importance of the need for new studies of consumer purchases in order to give effect to the post-war pattern of expenditure. The final chapter of the Report consists of a series of proposed resolutions.

This document does not pretend to be an exhaustive treatise on the nature of international retail price indices. Its main purpose was to guide and keep the mind of the Conference on the relevant item of the agenda when it came up for discussion, and to indicate post-war problems as they touch upon the measurement of retail prices. The Report is thus an interesting and well presented conference paper. R. F. G.

5.—*Report of the President's Committee on the Cost of Living.* Office of Economic Stabilization, Washington, 1945. 9″ × 6″. v + 423 pp. 60 cents.

In the autumn of 1943 the War Labour Board, at the suggestion of the President, appointed a Committee representative of labour, business and Government to examine the Bureau of Labour cost of living index figures with a view to clarifying the general controversy for which the figures were then responsible. The two members representing labour interests proved their zeal by submitting a report within a few weeks of the appointment of the Committee. This report was passed for criticism to the Bureau of Labour and to the American Statistical Association, as a result of which a technical Committee was appointed to resolve the differences in the views expressed. In the meanwhile, other members of the original Committee had produced their reports, which in turn were passed on to other bodies for comment. By this time the reader is likely to suffer from a confusion of Committees and documents, but the Chairman of the main Committee bravely keeps his head above water and says that there emerges a clear picture of the cost of living index.

In the Chairman's Report the difference in concept between cost of living and standard of living and the statistical methods used by the Bureau of Labour are briefly described. The main criticism of the Bureau's index comes from the labour members of the Committee, whose strong comments are answered most effectively and with a quiet dignity by the technical Committee under the chairmanship of Dr. Wesley Mitchell. The general charge that the index under-estimated the rise in the cost of food and in rents is firmly rebutted by all the independent statisticians, whose comments on the work of the Bureau are highly complimentary. After allowing for change in quality, increased tendency for price rises to be under-reported, loss of cheaper consumption items and similar detailed criticisms, the Mitchell Committee calculate that the official index should perhaps be increased by 3 or 4 points (of which half is attributed to the intangible quality factor), whereas the labour representatives had argued for an increase of no less than 20 points.

The Report proceeds to discuss the wartime changes in the American manner of living, and emphasizes that the index cannot be applied indiscriminately to all members of the population. The fact that its application is strictly significant only for a certain class of person in certain communities will not surprise statisticians familiar with the precise limitations of index numbers.

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In the result the Chairman reports that no substantial criticism of the index has survived the very careful studies made both of the criticisms themselves and of the index as such.

The Chairman's Report is followed by a separate report from each of the labour members of his Committee (in the main both hostile in tone) and by a joint report from the industrial members (substantially friendly). Of the several further reports appended, by far the most powerful is that of the technical Committee, which, besides dissecting the official index in detail, discusses the basic principles underlying the purpose and construction of a cost of living index. The comments made in reply to this particular report by the labour members of the Committee are not very effective.

In general terms, this publication implies a basic difference of opinion on the merits of the index between the representatives of labour and all other parties, and which their deliberations together as a Committee failed to resolve. The most important contribution to the Report is undoubtedly the document prepared by Dr. Mitchell's technical committee, which should be studied by all who are interested in the technique on which the Bureau of Labour's Cost of Living index number is based.

R. F. G.

6.—*World Fiber Survey*. Food and Agricultural Organization of the United Nations. Washington, D.C., U.S.A. xii + 176 pp. $1.00.

This survey was prepared in the Economics, Marketing, and Statistics Division, Commodities and Commercial Policies Branch of the Food and Agricultural Organization, by Dr. Gerda Blau, Chief of the Fibers Section, and by members of the Fibers Section staff. Most of the chapter dealing with wool was read before the Society in 1946, and is printed in the JOURNAL (Vol. CIX, Part III) under the title, "Wool in the World Economy."

The first part of the survey deals with world fibre requirements and supplies on a general basis, while the second part examines the position with regard to each main fibre or fibre group in turn. Although a wide subject is covered in a comparatively short space, the main factors affecting the total requirement and supply situation have been dealt with quite thoroughly. Dr. Blau and her staff are to be congratulated on an interesting and comprehensive piece of work.

At the moment the supply of unmanufactured fibres is not one of the world's most serious problems. There are some particular shortages, but on the whole they are confined to the group of fibres having industrial end uses. As far as apparel and household textiles are concerned, the restrictive factors in the fibre situation which are the cause of the present dearth in these commodities over a large part of the world are shortages of foreign exchange and shortages of manpower for the manufacturing processes. Any rapid and simultaneous easement of these two difficulties would soon bring about an acute shortage in the world's raw material resources, but such a possibility is remote, and the most that can be reasonably expected is a gradual easement to which the supply of fibres should be able to adapt itself.

The survey is optimistic about the long term supply situation. In the first place, when food crops return to normal in war devastated areas, a certain amount of land will be released from food production in other parts of the world and become available for the fibre crops it carried before the war. In the second place, certain fibre-growing areas in the eastern hemisphere which have suffered neglect owing to the war and its after-effects will also help to swell world fibre supplies on recovery. Thirdly, the possibilities of improving the yields from fibre crops over a large part of the world are now greater than ever.

During the last few years there has been a substantial increase in world population, but bearing in mind the gluts in natural fibres which were a not uncommon feature of pre-war years, these facts give some assurance that future prospects for plentiful natural fibre supplies are excellent. On top of this, there is every indication that the expansion in the production of man-made fibres experienced in the pre-war years is by no means halted, and that the next few years might bring some remarkable developments in this field. Looking ahead, the survey concludes that the pattern of world fibre supply is one of potential abundance.

Such an abundance, however, is extremely likely to lead to serious inter-fibre competition, causing particular hardships to those regions of the world having a high degree of dependence on the fortunes of a single fibre crop. On the basis of pre-war experience, the outcome would doubtless be the re-introduction of restriction schemes for natural fibre production, if the problem were left in the hands of the producing countries alone. Many importing countries would then seek security and stability by encouraging the use of man-made fibres, and this would further undermine the position of the natural fibre producers. The survey accordingly suggests that equilibrium in the post-war world should be based on an expansion of world demand rather than a restriction of supply. This is an application of the accepted international policy of achieving an expanded world economy with higher standards of living everywhere. It is a positive policy,

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and socially, it is much healthier than restriction, but whether it falls within the realm of practical politics is another question.

Of all the possibilities of inter-fibre competition, the most fascinating is that between natural and man-made fibres. Post-war trends, so far as they go, seem to suggest that nylon has already triumphed in its battle with silk. In current markets there is a strange reluctance to demand the latter, which, in spite of extreme shortness of supply relative to pre-war standards, is by no means out of step with regard to price. Rayon is a particularly insidious enemy of wool and cotton. To a certain extent, it can be mixed with either, yet the product resulting still retains the principal characteristics of wool or cotton cloth. Thus rayon eats into the demand for raw wool and raw cotton without having to face the formidable difficulty of displacing them outright in the finished goods market. Nevertheless pure rayon has, in fact, had remarkable success in displacing cotton and wool, and there has even been talk of attempting to produce a cotton with some of the characteristics of rayon in an endeavour to recover lost ground for the natural fibre. To a manufacturing country without natural fibre resources of its own, rayon has two particularly important advantages. Firstly, the range of raw materials available for its manufacture is wide and growing wider, so that raw material supply is unlikely to become a serious problem. Secondly, foreign exchange difficulties favour the production of rayon. Once production capacity is installed it is unlikely to fluctuate in the degree of its operation in response to changing market conditions for natural fibres. The substitution tends to be irreversible. Thus man-made fibres appear to be very dangerous competitors.

One final factor in the future situation of fibre processing may be mentioned. Countries which are attempting to foster industrial development owing to the interruption in their supplies of manufactured goods from traditional sources suffered during and after the war, or owing to more general national aspirations towards industrialization, are turning to the development of textile manufactures. On the basis of past experience, this has come to be the recognized first step in introducing industry to a non-industrial country. Such development, however, is not being confined to natural fibre processing as was the case after the first World War, but now embraces the man-made fibres. The survey mentions three countries in which rayon plants have been set up during the last few years, and eight countries with plans in hand for the establishment of plants. Added to this is the fact that many of the old textile manufacturing countries which have suffered from war-time devastation and dislocation are looking to an early restoration and expansion of their textile industries as an important step towards recovery. In the disposal of the finished goods, emphasis is generally on the export markets, since shortage of foreign exchange is one of the chief obstacles to recovery. In these circumstances the danger of creating surplus manufacturing capacity becomes very real.

The survey is silent as regards this possibility, but this is doubtless due to the fact that industrial problems are only on the fringe of the Food and Agricultural Organization's interests. It is nevertheless quite clear that no expansionist policy could be effective should manufacturing capacity with its boundless possibilities for growth outrun the supply of raw materials. If the possibility does exist there would seem to be a real need for some co-ordination in national industrial development and reconstruction plans. Otherwise, the unfortunate experience of Lancashire since the 1920's may be repeated in the 1950's over a wider range of textile industries in Western Europe and elsewhere.

T. M. R.

7.—*Housing and the Family*. By M. J. Elsas. London: Meridian Books, 1947. $7\frac{1}{2}'' \times 5''$. 136 pp. 8*s*. 6*d*.

In 1944–45 Dr. Elsas undertook a special enquiry for the Population Investigation Committee into the problem of housing in relation to demography. The results of this enquiry, together with private research before and since the war, provide the material on which this book is based. The special enquiry, however, accounts for only one chapter, the remaining eight consisting of work carried out by Dr. Elsas independently. Each chapter is closely packed with factual matter, and only the briefest conclusions are given in the text. The reader, therefore, has ample scope for extending the commentary which Dr. Elsas appears to have subordinated to the presentation of the facts.

The number and ages of existing houses in England and Wales are examined in the opening pages, and it is estimated that in 1945 roughly one-third were 80 years or more old, one-third between 30 and 80, and one-third less than 30 years. The number of houses at each census year since 1851 is considered in relation to population changes and the number of marriages.

The special questionnaire for the enquiry of the Population Investigation Committee was sent to 25 Housing Authorities, and replies were received from 10 County Boroughs, 4 Boroughs, 1 Urban District and 3 Rural District Councils. The answers to the 11 major and 11

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minor questions are reproduced in full. The object of the enquiry was to obtain particulars about Local Authorities' Housing Schemes during 1919–40 by asking for certain quantitative and qualitative information. The smallness of the sample clearly subjects the enquiry to severe limitations, and, recognizing this, the author discusses the results very strictly with regard to the Authorities concerned. The inter-war housing achievements of these Authorities would, nevertheless be illuminated by appropriate demographic statistics such as Dr. Elsas applies in other chapters for the country as a whole. When considering this material for the 18 Councils concerned, the Population Investigation Committee will doubtless look at it in the light of the local demography. As it stands it is a severely factual record of what those Authorities achieved during some 20 years by way of the number and types of houses for which they were responsible.

As the last census was taken in 1931, information on the size and condition of dwellings in England and Wales is not as adequate as could be wished. The Overcrowding Survey of 1936, however, provides invaluable supplementary information, and for the first time described the housing conditions of the population other than the well-to-do. Dr. Elsas freely draws on both these sources, and presents the essential detail with clarity and conviction.

Section V of the book is devoted to "Housing Indices," such as the ratio of the number of dwellings to the number of private families. The basic data, however, are drawn from the decennial housing census, and these criteria are thus mainly of historical value. To overcome this difficulty, the author has developed a housing index based on the ratio of the number of dwellings to the number of adults, and he estimates this index for March, 1945, to be 94 compared with 100 in 1939. This index cannot completely indicate the deterioration of the housing position, since the estimate of the adult population excludes those killed by enemy action at home and abroad and, moreover, the index cannot take into account those qualitative factors such as dilapidations, of which we are all too conscious.

The Government's housing policy, the magnitude of housing needs and the effect of rent rebates lead to the final chapter of the book. In this Dr. Elsas asks for certain annual housing statistics, including information on empty dwellings, a quinquennial housing census and a definition of the "household" which will bring out the number of hidden families, such as the young married couple who, living and boarding with others, remain obscured in official statistics and who yet require a dwelling of their own.

This book is an example of careful compression in which the facts are concisely presented, while the conclusions drawn are never allowed to stray beyond the limits of the evidence.

R. F. G.

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STATISTICAL NOTES

(1) British Official Statistics

The table below shows, in summary form, movements in the oversea trade of the United Kingdom in the first quarter of 1948, together with comparable figures for 1947 and the year 1938.

The value of United Kingdom exports increased by £33 million over the fourth quarter of 1947 to £353·4 million, the highest recorded figure since 1920. Retained imports (£472·1 million) increased by the same amount so that, as in the preceding quarter, the visible adverse balance shown by the official statistics amounted to £119 million, compared with £204 million in the third quarter of last year.

Total imports in the quarter were valued at £487·5 million; after allowing for the increase of 173 per cent. in average values of imports compared with 1938, the volume is estimated at 12 per cent. lower than in the pre-war year. Re-exports, valued at £15·4 million, are estimated at two-fifths of the 1938 volume.

The increase for retained imports was almost entirely accounted for by larger imports of food, drink and tobacco, which, after a heavy fall between the third and fourth quarters of 1947, showed a partial recovery to £205·5 million (73 per cent. of the 1938 volume). In this class the most important features were increases of roughly three-fifths over the low fourth quarter figures for both dairy produce (£35.5 million) and fresh fruit and vegetables (£23·0 million), together with a sharp increase in supplies of feeding stuffs; the only important reduction was that for tobacco, which fell by over a half to only 56 per cent. of the 1938 volume.

Retained imports of materials, £146·2 million—90 per cent. of the 1938 volume—showed only a small increase over the preceding quarter. Substantial increases for cotton (79 per cent. of the 1938 volume), wool (110 per cent.) and rubber (three-quarters higher than in 1938) were partly offset by the seasonal reduction for timber (to 53 per cent. of the 1938 average). Among manufactured goods, reductions for manufactured oils (mainly refined petroleum), non-ferrous metals and chemicals all contributed to the small reduction compared with the preceding quarter.

Average values of United Kingdom exports are now 139 per cent. higher than in 1938; after allowing for this increase the volume for this quarter (126 per cent.) is stated to be the highest achieved since the beginning of 1930.

In spite of a substantial reduction for tobacco, exports of food, drink and tobacco (£22.9 million) increased to 104 per cent. of the 1938 volume. Coal exports (1 million tons) equalled those in the whole of last year, but were still less than one-eighth of those in 1938; for raw materials as a whole exports were still only 27 per cent. of the 1938 volume.

£ million

	1938	1947 First half	1947 Third Quarter	1947 Fourth Quarter	1948 First Quarter
	Quarterly average				
Retained Imports, c.i.f.					
Food, drink and tobacco	104·5	197·1	227·3	176·4	205·5
Raw materials and articles mainly unmanufactured	54·5	109·0	158·6	140·9	146·2
Articles wholly or mainly manufactured	53·8	79·8	114·8	116·3	113·1
Other articles	1·7	5·7	5·6	5·2	7·3
Total	214·5	391·6	506·3	438·8	472·1
United Kingdom Exports, f.o.b.					
Food, drink and tobacco	9·0	13·9	17·7	19·3	22·9
Raw materials and articles mainly unmanufactured	14·2	9·6	7·8	7·2	11·6
Articles wholly or mainly manufactured—					
Metal goods	43·9	120·9	149·5	158·7	173·4
Textiles	25·3	52·8	57·2	62·1	68·8
Other manufactures	22·1	51·5	61·1	60·0	65·5
Other articles	3·2	8·6	9·1	12·8	11·2
Total	117·7	257·3	302·4	320·1	353·4
Exports of Imported Merchandise, f.o.b.	15·4	18·0	11·1	12·1	15·4

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Exports of manufactured goods reached a new post-war record of 143 per cent. of the 1938 volume, compared with 133 per cent. in the preceding quarter. The metals groups taken together were 86 per cent. higher than in the pre-war year, increases for the individual groups ranging from 9 per cent. for iron and steel to 145 per cent. for vehicles; for the largest group, machinery, exports totalled £56·5 million and, in terms of volume, were three-quarters higher than in 1938.

Textiles exports showed a further small increase (6 per cent.) to 82 per cent. of the 1938 volume. Exports of cotton goods (£25·7 million) are still little more than half of the pre-war volume, but for woollen and worsted manufactures (£21·0 million) the 1938 average was exceeded by one-sixth.

Among the remaining groups of manufactures, the two largest—miscellaneous manufactures (£19·9 million) and chemicals (£19·1 million)—were one-fifth and one-half respectively above the 1938 volumes, while shipments of pottery, glass, abrasives, etc. (valued at £10·7 million), reached a new record—nearly double the volume in the pre-war year.

The annual *index number of agricultural prices* calculated by the Ministry of Agriculture for the calendar year 1947 shows a substantial increase over previous years, the general index having risen to 212, as against 183 in 1946 and 173 in 1945. This is the highest figure recorded since these index numbers were started in 1906. In the pre-war period 1937–39 the corresponding figure was 90½. The changes in the past five years are shown below for the three groups of commodities which make up the index number. Allowance is made for Government subsidies, including payments in respect of acreage under wheat and potatoes, based in the case of wheat on estimated quantities entering into sale and in the case of potatoes on estimated total production. There has been some modification in these calculations, and the figures for earlier years have been slightly revised. The acreage payments as now calculated were equivalent in the case of wheat to 4*s.* per cwt. in 1946 and 2*s.* 11*d.* in 1947; for potatoes they were respectively 28*s.* 5*d.* and 31*s.* 6*d.* per ton.

(Base 1927–29 = 100)

	1943	1944	1945	1946	1947
Cereals and farm crops	177½	177½	183	183	195
Live stock and live stock products	151½	158½	164	178	199
Fruit, vegetables and glasshouse produce	204	204	193½	201	288½
General index	163	169	173	183	212

Although there were a few exceptions, nearly all commodities entering into the index showed a rise in 1947. Among important items, the index for wheat rose from 180 in 1946 to 191 in 1947, for potatoes from 165 to 181, for fat cattle from 156 to 183, and for milk from 206 to 221.

In connection with these rising prices, it may be noted that the *Economic Survey for 1948* (Cmd. 7344) mentioned that, in order to provide an adequate stimulus for the adoption by farmers of the agricultural programme as a whole, full allowance for certain capital outlay as well as some element of incentive had been made in the prices and other forms of assistance announced in August, 1947, including recoupment for known or expected increases in costs up to February, 1948.

The interim index of retail prices compiled by the Ministry of Labour and National Service showed an increase of 2 points in February, when it rose from 104 to 106 in consequence of increased prices for bacon and eggs, which raised the food index by nearly 5 points, and a further increase of 2 points in April, due mainly to higher duties on drink and tobacco. The clothing figure showed a rise of 3 points between January and April. The detailed figures for January, February, March and April were as follows:

(Prices at June 17, 1947 = 100)

Date	*Food*	*Rent and Rates*	*Cloth-ing*	*Fuel and Light*	*House-hold Durable Goods*	*Miscel-laneous Goods*	*Services*	*Drink and Tobacco*	*Total*
Weights	348	88	97	65	71	35	79	217	1,000
Jan. 13, 1948	103·6	100·1	102·7	109·2	107·5	111·1	103·5	104·1	104
Feb. 17 ,,	108·3	100·1	103·6	110·1	107·6	111·2	104·3	104·1	106
Mar. 16 ,,	108·8	100·1	104·9	110·1	107·7	111·2	104·6	104·1	106
April ,,	109·3	99·1	105·7	109·7	107·3	108·6	104·7	110·8	108

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In publishing the figures the Ministry of Labour states that they are in the form in which they are used in the procedure adopted for calculating the index for all the groups combined, i.e. to the nearest first place of decimals. The decimals are shown only in order that, if desired, calculations can be made of the effect of combining particular groups and excluding others. The information available as to price changes, however, is such that no precise significance can be attributed to the decimals, and for any other purposes, therefore, the figures should be used to the nearest whole number.

There was a slight decrease in the total working population in January to March, but the wastage rates for both men and women remained well below the average for 1947 and the decline was smaller than had been anticipated. The number of workers in civil employment, on the other hand, rose by 6,000 in January, by 29,000 in February, and by 11,000 in March. In each month there was a slight decline in the number of women. The following table shows the figures for January, February and March.

Thousands

	Total Working Population (excluding indoor private domestic service)			*Numbers in Civil Employment**		
	Men	*Women*	*Total*	*Men*	*Women*	*Total*
Dec., 1947	14,659	5,764	20,423	13,252	5,635	18,887
Jan., 1948	14,654	5,757	20,411	13,265	5,628	18,893
Feb. ,,	14,645	5,751	20,396	13,294	5,628	18,922
March ,,	14,663	5,724	20,357	13,326	5,607	18,933

* Including N.F.S., Police and Civil Defence.

The level of unemployment, which had been rising slightly from September, 1947, to January, 1948, declined in February and March, and rose slightly in April. The figures for January to April, which are given in the following table, are not strictly comparable with those available for earlier months owing to the cessation of the practice of excluding non-disabled persons who had been classified by interviewing panels as unsuitable for ordinary employment. These numbered about 8,000 in December, 1947. The figures for April, 1947, which are given for comparison were partially affected by the fuel crisis.

Number of Unemployed Persons on the Registers of the Employment Exchanges of the Ministry of Labour and National Service at the Undermentioned Dates

Date	*Insured Unemployed.*			*Total (Insured and Uninsured)*
	Men and Boys	*Women and Girls*	*Total*	
Jan. 12, 1948	238,566	79,681	318,247	331,477
Feb. 16 ,,	236,482	78,884	315,366	328,104
Mar. 15 ,,	227,162	72,243	299,405	311,221
April 12 ,,	231,928	68,912	300,840	314,672
April, 1947	318,343	108,646	426,989	442,741

The total for April, 1948, includes 32,852 married women and 9,576 ex-Service personnel who had had no employment since leaving the Forces. The 13,832 uninsured persons on the register included 1,716 boys and girls under 18 who had not yet entered industry. The totals do not include registered disabled persons who were classified as suitable only for employment under sheltered conditions.

The Censuses of Production and Distribution.—The Statistics of Trade Act, 1947, lays it down that a Census of Production shall be taken annually, commencing with a census for the current year, to be taken in 1949. The schedule to the Act lists the matters about which questions may be asked, and includes all those recommended by the Census of Production Committee under Sir George Nelson in 1945. The form of these questions was tried out at the Partial Census of Production for 1946. This covered 11 industries, including Building and Mechanical and Electrical Engineering, and each of these was asked one or more of the new questions. Useful experience was thus gained, and the Census of Production Advisory Committee for the 1948 Census recommended some modifications in the form of the questions as a result.

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A preliminary form of notification of the questions that it was proposed to ask for 1948 was sent last January to every factory, workshop, mine, builder, public utility or other productive undertaking. Apart from a few industries, for which special schedules were prepared, these forms of notification were in two parts, the first containing questions common to all industries, such as those relating to employment, wages and salaries, buildings, machinery and plant, and the second relating to the particulars individual to each industry, such as output, materials and stocks.

In a few industries—building, baking, printing, etc.—where production by the small firms forms a considerable part of the total, firms employing up to 10 persons, including any working proprietors, will have to provide some simple particulars about their output and materials, but generally speaking these small firms will only have to say how many persons they employed.

Publication of the results of the 1946 Partial Census of Production has only recently commenced, the first report being published in the Board of Trade Journal on March 6. These are only preliminary results, as some returns are still outstanding, and a great speeding up will be needed if all the 1946 results, final as well as preliminary, are to be published by the beginning of 1949, when the 1948 Census is due to be taken. If the final results of the Partial Census take two years to publish, what is the chance that the results of a full census can be published in about a year? Yet that is what must happen if one census is not to run into the next. It must be remembered, however, that there was a certain amount of opposition—mainly passive resistance—to the Partial Census, merely because it was partial and firms objected to furnishing returns that were not being required from everybody; also it was the first time the rather elaborate census questions had been asked since the war, the census was taken under the Defence of the Realm Regulations and not directly under an Act, 1946 was a difficult year for industry, and, most important, no preliminary form of notification was sent out. All of which was bound to lead to much correspondence and to delay in sending in returns and a corresponding delay in publication of results. Publication actually began five months earlier than for any earlier Census or Import Duties Act Inquiry, so the Board of Trade have made some advance, but they must do far better for 1948.

The Statistics of Trade Act made provision for taking a Census of Distribution in any year prescribed by an Order made by the Board of Trade. No such Order has yet been made, but in replying to a Parliamentary Question on May 25th, the President of the Board of Trade said it had been decided to take the first census under the Act in 1950 in respect of the year 1949. This will thus coincide with the taking of the second annual census of production, and quite obviously many difficult problems will have to be faced.

It was with these problems in mind that the Census of Distribution Committee under Sir Richard Hopkins recommended that a national census should be preceded by a Pilot Census. Such a census has been taken this year in respect of 1947 and the results will be placed before the Advisory Committee which the President of the Board of Trade said he was proposing to appoint. The Pilot Census covered three counties, which will give experience of enumeration in rural areas, and a number of towns of various sizes and types, selected for special reasons so as to enable the Census Office to come up against as many as possible of the administrative difficulties likely to be met with in taking a census.

The Board of Trade have tried out at the Pilot Census a number of kinds of schedule, varying from one containing all the questions suggested by the Census of Distribution Committee to one containing a minimum number of questions. In all there were six different schedules for retailers and others for caterers, motor garages, wholesalers and the service trades, such as hairdressing and boot and shoe repairing. The variation in the response to the different types of schedule should help in determining the most appropriate questions to ask at the first Census. But there has been some organized opposition to the Pilot Census by certain local Chambers of Trade, and the response in these areas will be coloured by this fact and therefore not very useful for comparative purposes. Other matters for which various methods were tested included the preparation of the register and the collection of the returns. It may be hoped that the Board of Trade will publish a report giving the results of the Pilot Census; even though the figures for various areas may be biased owing to a poor response to the questionnaires, the total number of returns may be adequate to enable some relationships to be investigated, and it would be interesting to know what was discovered about the distribution of shops as shown by the register. Every scrap of information adds to the very meagre knowledge available concerning this important branch of our national life.

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(2) Other Statistics

Lloyds Bank Deposits Index.—The latest addition to banking statistics is an index of clearing bank deposits adjusted for seasonal variations, prepared by Lloyds Bank. This appears to be the first attempt to eliminate the well-marked seasonal variations in deposits in order to reveal

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the underlying trend. It is understood that in compiling the index, deviations from a twelve-months' moving average covering the period 1933–1947 were expressed as a percentage of deposits in the month to which the deviation refers. While the deviations varied fairly widely from year to year, there was no indication of any secular change in the seasonal pattern that would have precluded the use of a single series of monthly adjustments applicable to the whole period. The resulting monthly values of the index were smoothed by a five-months' moving average, except over the turning-points in the trend. From the outbreak of war until the end of 1946 this has shown a continued rise interrupted on only two occasions: following the introduction of tax reserve certificates in December, 1941, and during the Thanksgiving savings drive of late 1945.

Since the end of the ultra-cheap money drive in early 1947 there has been a marked flattening of the upward movement. Indeed, from a temporary peak of 249·3 in April, 1947 (1938 = 100), the index declined to 246·1 in September, but has since advanced once more to a new peak of 259·0 in March, a conversion operation and disbursement by the Treasury of the proceeds of sale of the Argentine railways having caused a record jump of 7½ points in the latter month. Owing to the recent change of trend, the smoothing process was continued only up to the end of 1946. Thereafter the monthly figures have been used without further adjustment and are described as provisional, for periodic revisions will probably be needed, as the seasonal pattern is never completely stable.

The *Committee of Lloyd's Register of Shipping* have recently issued to Subscribers the Appendix to the 1947–8 edition of Lloyd's Register Book. This Appendix, which, owing to the exigencies of the war, is the first to be issued since 1939, contains much information of interest and value to the shipping community. Included in the book are Statistical Tables giving extensive and precise information respecting the various merchant fleets of the world. Such Tables were first published in 1886 and, with the exception of two years in the first world war and from 1939 to the present time, have since been issued annually. In their main characteristics they thus form a very valuable series of statistical data.

The General Notes at the beginning of the Section indicate the bases upon which the figures have been compiled. As heretofore, the Tables are based upon the entries in Lloyd's Register Book as printed and published in July. They therefore do not reflect any changes in the British Commonwealth of Nations or elsewhere for which the operative dates have been subsequent to July 1, 1947. It is further pointed out that figures for Great Britain and Northern Ireland at the end of June, 1947, include ships on bare-boat charter from the United States of America and from Canada, and that the figures for the United States of America include ships in the Reserve Fleet.

In view of the exceptional changes in the distribution and allocation of ships which must always occur after a prolonged war, and which are still continuing, the figures in the Tables should be regarded as indicating an intermediate stage in the transition from war-time to peace-time conditions. They are nevertheless welcome and will repay careful study, as they provide as accurate a picture as is at present possible of the composition and disposition of the world's sea-going shipping. It is hoped that figures based on the 1948–9 edition of the Register Book will furnish a more consistent and stable record of the position of the merchant fleets of the world.

In some Statistical Notes on the Appendix, there are presented, subject to the foregoing and other necessary reservations, various comparisons with the pre-war position in 1939 and at certain other dates.

The world's total gross tonnage is now shown as 84.4 million tons, compared with 69.4 million tons in 1939. Much interesting information is also given concerning types of vessels and their machinery and fuel, and regarding the size and age of steamers and motorships, etc. etc.

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CURRENT NOTES

The Calcutta Statistical Association has sent the Society the first number of its *Bulletin*, dated August, 1947. An introductory note states that the Association was founded (in 1945) "with the object of promoting the cause of statistics in post-war India in all possible ways," and was initiated by members of the staff of the Statistics Department of Calcutta University, with which it works in close collaboration. The promoters believe that there is an urgent need in India for educating both the Government and the public in the right use and understanding of statistics, in order to ensure their accuracy and trustworthiness, especially at this time when national programmes of development are in contemplation. Attention is drawn to the very small number of organizations at present available for the necessary work, and to the guidance which the Association is ready to give to statistical bodies and to individual statisticians in carrying out tasks such as sampling enquiries, analysis of data and so on. The *Bulletin* aims at "popularizing" statistics, by explaining statistical methods and their application and by publishing accounts of statistical work being done in India, together with notes on research and other current matters.

The contents of this first issue include, beside the Introduction and the rules of the Association, five papers designedly elementary in character: Crop Estimation, by Birendranath Ghosh, of Presidency College, Calcutta, gives a brief survey of sampling methods (which date from the time of Akbar), and noting the modern scientific developments, notably the advances made possible by the work of Professor Neyman and Professor Mahalanobis. A Survey of Public Opinion by M. N. Ghosh advocates the adoption of methodical enquiries into popular preferences, needs and circumstances, on the lines of the British *Social Survey;* it suggested that a special Institute should be set up in India for this purpose. H. K. Nandi writes on the Misuse of Statistics, whether wilful, for propaganda or biased reasons, or unintentional, because of inadequate, inaccurate or ill-understood data and the use of elaborate methods by persons not sufficiently acquainted with the nature of the material to which they are applied. Mr. P. K. Box contributes a short explanation of Mental Tests; and the last paper, by S. Bhattacharyya, is A Critique of the Report of the Central Pay Commission (on the wages and salaries of government employees), which the writer considers to have failed in its object, or at least, in what should have been its object, since the recommendations of the Commission were not based on any family budget enquiry, and thus bear no direct relation to a minimum standard of living.

The *Bulletin* further contains Critical Reviews of statistical publications, Research Notes (methodological) and Current News, the first of these being on India's role in world statistical organizations. It should be noted that the Secretary of the Association is Purnendu Kumar Bose, M.Sc., Lecturer in the Department of Statistics, Calcutta University, to whom all communications should be addressed.

The first number of a new Italian periodical, the *Rivista Italiana di Demografia e Statistica*, dated January, 1947, has reached us. It is the organ of the Società Italiana di Demografia e Statistica, which was founded before the war and held three meetings in 1938 (in Rome, Florence and Bologna respectively), but was in abeyance during the period which, as the introductory article puts it, dislocated the slow but sure advancement of the national life. This Introduction (*Presentazione*) is by Professor Lanfranco Maroi, who is the Director. The names of the members of the scientific committee assisting him are equally well known and respected in this country; they are Professors Livio Livi, A. Niceforo, F. Savorgnan, G. Tagliacarne and F. Vinci. In the *Presentazione* Professor Maroi sets out and discusses the aims and scope of the publication. Briefly, the intention is to develop the science of demography to the fullest extent, not confining it to numerical studies of population as such, but investigating all problems relating to population in a sociological sense, biological, psychological and economic, by means of statistical methods adapted to the several species of material; also, in order that the treatment may be soundly based, articles on statistical theory will be included.

In this first issue Professor Savorgnan discusses Galton's theory of the inheritance of fertility; G. Palomba criticizes methods founded on mass observations, as exemplified by Irving Fisher's celebrated equation of exchange; Professor Livi contributes an enquiry into the cost of house-building in Italy, with special regard to the percentage costs of the constituent items and their respective changes since the pre-war period. A. Occhiuto shows the sex and age distribution of the Italian electorate in 1946, with forecasts for 1951 and 1956; Professor G. Colombo reviews the recent development of sampling enquiries, particularly drawing attention to those carried

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out by British Government Departments during the war, (of which he enumerates forty-three in all, beginning with ten each by the Ministry of Food and The Board of Trade). These main articles are followed by *Rassegne*—reviews or surveys; in this number these deal with demographic disturbances in the war period (E. d'Elia), the economic cost of the second world war (B. R. Ragazzi) and methodological statistics (A. dal Chiaro), the last a review of two recent Italian works and one French one on economic-statistical methods.

A section headed Statistical Activity comprises an investigation into the distribution of landed property in Italy (A. Spagnoli), an account of the work being carried out by the Istituto Centrale di Statistica, which resumed its activities at the earliest possible moment and is busily expanding them, and, lastly, a note on the Statistical Union of Italian Cities, founded in 1905 but superseded in 1926, perhaps not entirely for the best, by the Central Institute. The remaining pages of the *Rivista* contain reviews and a bibliography of recent works, announcements of forthcoming publications and a summary of the contents of current statistical periodicals, Italian and foreign. Altogether, a publication full of matter and under expert guidance.

The National Bureau of Economic Research completed the 25th year of its activities in June, 1945, and a year later celebrated the occasion by an Anniversary Meeting. The papers read have been published in a volume entitled *Economic Research and the Development of Economic Science and Public Policy*. The larger number are concerned with broad aspects of the functions of economic research, and of economists, in relation to public policy; the remainder illustrate the requirements by reference to particular applications. In the first category are "Empirical Research and the Development of Economic Science," by Wesley Mitchell; "What the Policy Maker Needs," by Alexander Loveday; "Some Comments on Research Method," by Harold G. Moulton; "Translating Facts into Policy," by E. A. Goldenweiser; "Economic Facts and Economic Policy," by Lewis W. Douglas; "Considerations by the Way," by R. H. Coats; and "Whither Now," by Joseph E. Davis. The last-named summarizes the general feeling that the occasion was one for considering the future work of the Bureau, and of economic research workers, rather than for dwelling on past achievements. All the contributors are agreed that Economics is as yet not a science but that it must become one, though this will take time and effort. Each discusses the kind of effort needed. Professor Mitchell defines the future job of economists as the determination of the way in which different elements in the economy can be adjusted; he looks chiefly to the development of empirical research and its combination with speculative enquiries—complementary and not antagonistic methods. Mr. Loveday emphasizes the need for the organization of international research, based upon a foundation of accurate and comprehensive national statistics, for which, as his audience knew, his own work at the League of Nations had prepared the way. Mr. Joseph Davis, Director of the Food Research Institute, Stanford University, asks economists to improve basic concepts, to evolve and refine laws of economic behaviour, and to give more scrutiny to official presentation. Mr. Harold G. Moulton, Director of the Brookings Institution, urges a continuous revision of economic theory, giving instances of the unfortunate results of "fundamentalism," and stresses the need for an intimate knowledge of economic processes. Mr. E. A. Goldenweiser says that the many figures collected are not sufficiently understood, and discusses the difficulty of presenting expert advice in a form which shall not only persuade the administrator, but will also enable the policy to be defended before government, parliament and the public, when some of its consequences may not be entirely agreeable. Mr. Lewis Douglas, then President of the Mutual Life Insurance Society of New York, advocates "long run systematic research into fundamentals" ("piecemeal enquiries are useful but often lead to doubtful action"), and, throughout, "the tedious and faithful pursuit of truth."

One of the papers dealing with special aspects is Professor Jewkes's "Second Thoughts on the British White Paper on Unemployment Policy." Since assisting in its preparation he has become conscious of uncertainties in the conception of the plan and of difficulties in the way of its execution; he considers that much statistical research is needed for the solution of certain problems—the minimum level of unemployment aimed at, the distinguishing of temporary or cyclical changes in the economic structure, the effect of changes in foreign trade, the ensuring that with "full employment" the standard of living shall be improved or maintained. Mr. Jacobson, economic adviser to the Bank for International Settlements, speaking on "International Research in Problems of Gold and Prices," considers that for the understanding of price trends much more study must be given to international statistics; economists should examine more fully the causes and phases of economic occurrences; credit policy often represents a choice between evils, and needs a careful balancing of factors, based on study of the past. Professor Warren, in "Twenty-five Years of Monetary Control," notes that monetary economics promised an answer to the problem of overcoming human deficiencies, but has not fulfilled expectations. M. Charles Rist deals with

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"Economic Research in France" and with the effect there of controls. He also has no doubt that the need is for the study of international phenomena by which national phenomena are so largely controlled in despite of national planning. Dr. Tinbergen—"Unstable Equilibrium in the Balance of Payments"—asks for investigations into the elasticity of exports, and stresses the value of econometric methods.

Mr. R. H. Coats, allusive, illustrative, and epigrammatic, exhibits a range of reading from Aristotle to the most modern authors, and an acquaintance with many sciences and arts. But the emphasis, as befits the former Dominion Statistician, is on statistics. He finds their progress in the 25 years a "cheering retrospect," and states his conviction that national statistics are a national necessity, but that their relation with departmental statistics, no less a necessity, should be, as it were, of a federal type, not a centralized dictatorship. He would like to see a still more comprehensive organization, and welcomes the revival of the International Institute of Statistics, as he deplores the end of the International Institute of Agriculture.

All the speakers congratulated the Bureau on its work in the development and clarification of economic knowledge, and looked to it for the furtherance of the several aspirations they had expressed.

The National Institute of Economic and Social Research now administers the funds of the Garton Foundation, established in 1918 in accordance with the will of Sir Richard Garton for the encouragement of the social sciences. In conformity with this purpose the Institute has decided to offer an annual prize, the *Sir Richard Garton Memorial Prize*, of the value of one hundred guineas. The first competition, to be held in 1948, is for the best original investigation into one of the following topics:

(*a*) The factors determining productivity in a particular industry; (*b*) a statistical study of incentives in relation to their economic effects in a particular industry or group of industries; (*c*) a contribution to the study of the incomes or expenditure of the middle income groups; (*d*) a contribution to the study of mobility in relation to location of industry.

Competitors who, in the course of their own work, consider themselves to be advantageously placed to investigate some other problem in applied economics, may ask to have an alternative topic accepted for competition, but for the current award such application must have been made not later than June 30, 1948.

The Institute is anxious to encourage research in applied economics among younger men and women, and has particularly in mind: relatively junior holders of academic posts and post-graduate research workers; younger people in business or industry in the Civil Service. Competitors should normally be under 30 years of age or, if they have been on war service, under 35 years. The prize is open to all such persons resident or normally resident in the United Kingdom. Published papers are not admissible unless they form a minor part of the essay submitted, the length of which should not exceed 30,000 words. The prizewinning essay will be published by the Institute.

Further particulars and the form of entry which must accompany each essay sent in may be obtained from

The Secretary,
National Institute of Economic and Social Research,
2, Dean Trench Street,
London, S.W. 1.

The University of London asks us to publish the announcement of its *Grants for Research*. Applications are invited from members of the University for grants from the Central Research Fund for assisting specific projects of research and for the provision of special materials and apparatus. Applications will be considered three times a year, and must be received not later than March 31, July 31 and November 30. Forms of application and further particulars may be obtained from the Academic Registrar, University of London, Senate House, London, W.C. 1.

Fellows will note with pleasure that Dr. Frank Yates has been elected a Fellow of the Royal Society and that Sir George Maddex, Government Actuary, has been elected President of the Institute of Actuaries for the coming year.

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OBITUARY

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SIR IOAN GWILYM GIBBON

The death on February 4, 1948, of Sir Gwilym Gibbon has removed from the Society one of its most vivid personalities. His capacity to think clearly and to express himself with vigour and strength was curiously associated with a certain shyness, and few had the advantage of knowing him really well. It was not only those few, however, who recognized the force of his character.

Gwilym Gibbon was of Welsh origin, the son of a mining engineer, born at Treherbert, Glamorgan, in 1874. He was educated at Oswestry High School, from which he entered the Civil Service as a second Division Clerk in 1893, being assigned to the Post Office, where he served in the Secretary's Department for 10 years. During this period he worked in his spare time for an Arts Degree at London University, which he obtained in 1898, and then for the First Division examination, achieving success in 1903, in face of the severe competition of graduates of the older universities, who then enjoyed a virtual monopoly in the examination. This achievement was then an exceedingly rare event, and only a man of exceptional capacity could hope for success. With his Class I Clerkship Gibbon entered the Local Government Board, and from the start showed marked ability. At this time he began to work privately at London University for his science degree, taking his Doctorate in the social sciences in 1911. In 1912 he became private secretary to Mr. John Burns, then Parliamentary Secretary to the Local Government Board, and in September, 1914, he took charge of the newly formed Intelligence Department. During the first world war he was made Secretary of the Central Appeal Tribunal, and responsible for the supervision of some 2,000 Tribunals throughout the country. In this work he was closely associated with the Adjutant-General and our former President, Lord Woolton. After the war, having been created a C.B.E., Gibbon became an Assistant Secretary and Director of Intelligence and Statistics; in 1921 he was given charge of most of the Local Government Division of the Ministry of Health, and here began the work for which he will be best and long remembered. He was responsible for the supervision of all the basic sanitary services of the country, such as water supply and sewerage, as well as for town planning, local legislation and finance. For the next 14 years he was concerned with all aspects of local government. He took a large part in framing the Local Government Act of 1929, and his evidence before the Royal Commission on Local Government has become a standard work of reference. Much of his time was devoted to the administrative aspects of town planning, in which he took the greatest interest. In 1925 he became a Principal Assistant Secretary, and six years later was awarded the C.B. For the last eighteen months of his official career he was Director of the Local Government Division, and represented the Ministry of Health on the National Council of Social Service. At the end of 1935 he retired from the public service and was created a Knight Bachelor.

From this brief record it is possible to imagine some of the qualities of the man who rose from humble position in the civil service to very high office. His capacity for work, for digging to the roots of a problem, was remarkable, and his intolerance of anything facile or superficial was proverbial. Although he did more than one man's work at the official desk, he found time to contribute effort and thought to other interests as well. With Lord Haldane and Sir John Anderson he was partly responsible for founding the Institute of Public Administration, in the affairs of which he was deeply interested. For many years he was an Honorary Member of the Institute of Municipal Treasurers and Accountants, whose annual conference in 1925 he addressed on the subject of "The Finance Officer and his Place in the Official Organization." His lectures and publications during the inter-war years ranged over Unemployment Insurance, Medical Benefit in Germany and Denmark, Infant Welfare Centres, Problems of Town and Country Planning, and a History of the London County Council.

Gibbon was elected a Fellow of the Society in 1918, and from 1938 to his death, with the exception of two years, he served on the Council. For five of these sessions he was a member of the Executive, and for three of them a Vice-President. He read a paper in 1936 on "The Expenditure and Revenue of Local Authorities," and a second on "The Public Social Services" in 1937.

Of his private life little was known. When he recommended a younger man to get to know as many members of a certain club as possible and that "as soon as you decently can," he added, "I am not preaching what I practise, because I am a reserved fellow." That was indeed true, and it was probably natural that he should endeavour to conceal his shyness beneath an abrupt manner,

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apt to terrify those who did not know him. In point of fact he was ever ready to place his deep experience at the disposal of those who sought his advice, and so prove himself a kindly and sensitive man. He had the unusual ability to withdraw himself from the detail of long experience and to see life as a whole, and to draw from it the main guiding lines of action. This ability developed a critical faculty that was essentially provocative, so that even if one disagreed with him, one was forced to delve deeply to discover why. His insistence on fact, accuracy, brevity and clarity of expression was the fruit of his distinguished official career. Gibbon had no time for fancy trimmings, but wanted information, statistical or other, so put "that the wayfaring man may understand." It must have been an exercise in stern personal discipline for him if he followed the advice he once gave a young man who had been appointed to a Minister's Private Office—"Treat Ministers and high superiors like kings, as though they were never wrong—and never show that you think otherwise."

In the Local Government Division of the Ministry of Health Gibbon created a legend, one that still remains. His forceful personality and clear and trenchant thinking will similarly remain in the minds of all who met him in the Society, while those few who were more closely associated with him will for long retain the memory of a notable man and a wise and kindly counsellor.

R. F. G.

Robert René Kuczynski, 1876–1947

Dr. R. R. Kuczynski, who died on November 25, 1947, was best known as a demographer and made his most influential contributions in that capacity. But during a long and productive life he contributed to many other fields, and his work showed a variety of interests which, even for his generation, must have been quite exceptional.

Born in Berlin, he attended the French *Gymnasium* in that city, and later studied at the Universities of Freiburg, Munich, Strasbourg and Berlin. His doctoral dissertation, *Der Zug nach der Stadt* (1897), already showed his interest in demography, and this interest was stimulated by Richard Böckh, Director of the Berlin Statistical Office, under whom he worked in 1898, and whose influence on Kuczynski's later demographic studies is evident. Seeking, as he always did, work which would give him both new practical experience and time for research, he then spent two years at the Division of Methods and Results of the United States Census Office. On his return to Germany he became Director of the Elberfeld Statistical Office, and subsequently, from 1906 to 1921, of the Berlin-Schoeneberg Statistical Office. He was also a lecturer at the Berlin *Handelshochschule*, edited two weekly news-letters, *Finanzpolitische Korrespondenz* and *Deutsch-Französische Wirtschaftskorrespondenz*, and published, during the inflation years, a weekly cost-of-living index. In 1926 he joined the faculty of the Brookings Institution of Washington and remained a member until 1932, though continuing for much of the time to live in Germany. He also took an active part in politics in Germany. He was a prominent member of the League for the Rights of Man, and was one of the first Germans to speak at public meetings in France and England after World War I. He was perhaps best known in politics for his association with the plebiscite for expropriating the Kaiser and the princes (*die Fürstenenteignung*), who were receiving substantial pensions from the Weimar Republic.

Kuczynski's published work up to 1932 covered a wide range of subjects, including pioneer studies of the history of wages, of German economic and financial problems, of food production and labour conditions. Demography was only one of the subjects, though there was a growing emphasis upon it towards the end of the period. During his first visit to the United States he had published papers on the fertility of native and foreign-born women and on the early registration laws of the New England settlements, and in 1907, in a report to the Fourteenth International Congress of Hygiene and Demography, he introduced the concept of the gross reproduction rate, the complement to the net reproduction rate invented by Böckh and first used by him in 1884. But he did not really again turn to demographic analysis until he had become a member of the Brookings Institution. Then, in addition to a number of books on American loans to Germany, he produced three studies which marked a new concern with demography—*The Balance of Births and Deaths* (1928 and 1931), *Birth Registration and Birth Statistics in Canada* (1930), and *Fertility and Reproduction* (1932).

In 1933, after Hitler had come to power, Kuczynski left Germany and joined the staff of the London School of Economics, initially as a research fellow of the Department of Social Biology, and later as Reader in Demography, the first university appointment in demography to be created in this country. In England he concentrated exclusively on demography, publishing *The Measurement of Population Growth* (1935) and *Population Movements* (1936), and beginning a series of studies of colonial territories, of which two have appeared—*Colonial Population* (1937) and *The Cameroons and Togoland* (1939). In view of his growing specialization in colonial demography,

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it was most fitting that, after his retirement from his Readership during World War II, he became Demographic Adviser to the Colonial Office. Age certainly did not interfere with his productivity. At the Colonial Office he was actively engaged in promoting new censuses. In this connection he visited the West Indies and planned visits to other parts of the Colonial Empire. At the same time he still vigorously pursued research, preparing a *Demographic Handbook of the British Colonial Empire*, of which the first two volumes will be published in the near future. He was working on this *Handbook* until a few weeks before his death. He was one of the original members of the Population Investigation Committee, and of the Statistics Committee of the Royal Commission on population.

Thus, although at all stages of his career Kuczynski was interested in population questions, they did not, as pointed out above, become his primary concern until after he had joined the faculty of the Brookings Institution. It is, in fact, remarkable that Kuczynski's main influence has been in a field on which he did not really concentrate until he was more than fifty years of age. This influence did not derive, in the main, from theoretical contributions, though the gross reproduction rate was a fertility index of considerable importance. What was of far greater importance, however, was the general way in which he looked at the processes involved in population growth. Although many other workers contributed to the development of modern techniques of demographic analysis, it is largely due to Kuczynski's influence that the new techniques are now widely used and that there has been, during the last twenty years, so marked a change in the whole approach to the quantitative study of population movements. His own studies were characterized by meticulous scholarship and integrity, and to these qualities were allied the belief that in demography statistical ingenuity was no substitute for adequate basic data.

Dr. Kuczynski was a man of outstanding charm and generosity. He gave eagerly of his help and advice to all genuinely interested in population questions, and in so doing played a leading part in the development of demographic studies in this country. His death is a serious loss to demography, and a great personal loss to all who knew him. D. V. G.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

Annals of Eugenics—

October 1947—A new estimate of the linkage between the genes for colour-blindness and haemophilia in man: *J. B. S. Haldane* and *C. A. B. Smith*. The dysgenic effect of induced recessive mutations: *J. B. S. Haldane*. Length of human gestation with special reference to prematurity: *M. N. Karn*. Phenylketonuria. Data on forty-seven British families: *T. A. Munro*.

The Banker—

December 1947—Reparations and partition: *M. J. Bonn*. Life assurance and population: *L. T. Little*. The dollar problem: *Roy Harrod*. Banks and the export drive: II—Methods of securing payment: *Service Etranger*.

Biometrika—

December 1947—On the distribution of the rank correlation coefficient when the variates are not independent: *Wassily Höffding*. The significance of rank correlations where parental correlation exists: *H. E. Daniels* and *M. G. Kendall*. Testing for normality: *R. C. Geary*. The stratified semi-stationary population: *S. Vajda*. A simple approach to confounding and fractional replication in factorial experiments: *O. Kempthorne*. A comparison of stratified with unrestricted random sampling from a finite population: *P. Armitage*. Some theorems on time series: *P. A. P. Moran*. Rank correlation between two variables, one of which is ranked, the other dichotomous: *J. W. Whitfield*. The variance of τ when both rankings contain ties: *M. G. Kendall*. A χ^2 "smooth" test for goodness of fit: *F. N. David*. An exact test for the equality of variances: *R. L. Plackett*. The estimation from individual records of the relationship between dose and quantal response: *D. J. Finney*. A numerical solution of the problems of moments: *H. O. Hartley* and *S. H. Khamis*. Approximation to percentage points of the z-distribution: *A. H. Carter*. Note on the cumulants of Fisher's z-distribution: *L. A. Aroian*. A note on the mean deviation from the median: *K. R. Nair*. On the method of paired comparisons: *P. A. P. Moran*. Notes on the calculation of autocorrelations of linear autoregressive schemes: *M. H. Quenouille*. Approximate formulae for the percentage points of the incomplete beta function and of the χ^2 distribution: *D. Halton Thomson*.

The Economic Journal—

September 1947—Cheap money and the budget: *Sir H. Henderson*. The measurement of national income and expenditure: *J. R. N. Stone*. Price theory and oligopoly: *K. W. Rothschild*. Home Counties farming, 1840–80: *G. E. Fussell*.

Oxford University Institute of Statistics, Bulletin—

November 1947—The technique and progress of Czechoslovakia's two-year plan: *P. D. Henderson* and *D. Seers*.

December 1947—Western Germany and reconstruction: *F. A. Burchardt* and *K. Martin*. Britain and the Geneva Tariff Agreements: *T. Balogh*.

AUSTRALIA—

The Economic Record—

December 1947—International economic co-operation and the Australian economy: *G. L. Wood*. The Australian social services contribution and income tax acts, 1947: *H. S. Carslaw*. The international monetary fund and the treatment of cyclical balance of payments disequilibria: *H. W. Arndt*. Landlords and tenant farmers of Japan: *K. Singer*. The New Zealand gold rushes: *E. P. Neale*.

INDIA—

Calcutta Statistical Association Bulletin—

November 1947—Organization of statistical work in India: *S. N. Roy*. Statistical organizations in India: *H. K. Nandi*. Agricultural labour in Bengal: *A. Ghosh*. Problem of jute industry: *H. K. Chaturvedi*. Money and business activity: *T. Ghose*.

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INDIA—*Cont.*

Sankhyā—

October 1947—On some analogues of the amount of information and their use in statistical estimation: *A. Bhattacharyya.* The existence of collectives in abstract space: *C. F. Kossack.* On a resolvable series of balanced incomplete block designs: *R. C. Bose.* On recursion formulae, tables and Bessel function populations associated with the distribution of classical D^2-Statistic: *P. K. Bose.* Notes on testing of composite hypotheses: *S. N. Roy.* On the general law of demand for raw jute: *T. P. Chatterjee.* Cyclic intra-block sub-groups and allied designs: *R. L. Plackett.* Factors influencing the relative proportion at birth of the two sexes: *N. T. Mathew.* A note on the scale of minimum wage for the jute mill workers of Bengal: *S. Bhattacharyya.*

UNITED STATES—

American Academy of Political and Social Science, Annals—

November 1947—The Motion picture industry. (Whole number.)

American Economic Review—

December 1947—Wage determination under collective bargaining: *A. M. Ross.* The annual wage: where are we? *H. Feldman.* The Webb-Pomerene Law: Capital growth and equilibirum: *T. C. Schelling.* Exchange control and discrimination: *H. S. Ellis.* The foreign trade multiplier: *J. J. Polak.*

American Statistical Association, Journal—

December 1947—Controlling bias in mail questionnaires: *J. A. Clausen* and *R. N. Ford.* Co-ordinating the measurements of radio listening: *Hans Zeisel.* A stratified-random sample of a small finite population: *F. G. Cornell.* Sampling methods applied to estimating numbers of commercial peach area: *F. E. McVay.* General methods of analysis for incomplete block designs: *C. R. Rao.* Tumbler mortality: *G. W. Brown* and *M. M. Flood.* The relative power of three statistics for small sample destructive tests: *P. H. Jacobson.* Simplified methods of fitting certain types of growth curves: *D. J. Cowden.* Lorenz curve analysis of industrial centralization: *G. C. Smith, Jr.* Agricultural price index numbers: *A. G. Peterson.* On the choice of forecasting formulas: *P. G. Hoel.* Use of variance components in the analysis in hog prices in two markets: *R. L. Anderson.*

Journal of Experimental Education—

September 1947—Appraising teacher personnel: *D. G. Ryans.* A comparative study of students preparing for five selected professions including teaching: *L. P. Blum.* A study of the professional curriculum requirements for the preparation of High School teachers in the United States: *K. R. Doane.*

December 1947—Speech content of selected groups of orphanage and non-orphanage pre-school children: *Jean K. Moore.* Development records of 500 nursery school children: *Ruth P. Koshuk.*

Journal of Political Economy—

October 1947—Lerner on the economics of control: *M. Friedman.* The kinky ologopoly demand curve and rigid prices: *G. J. Stigler.*

December 1947—The role of the international monetary agreements in a world of planned economies: *R. F. Mikesell.* Salvation by science: the gospel according to Professor Lundberg: *F. H. Knight.* Bank capital: the problem restated: *Tynan Smith* and *R. E. Hengren.*

The Milbank Memorial Fund Quarterly—

October 1947—Nutrition in the Ukrainian S.S.R.: *W. P. Forrest.* Chronic disease among spouses: *Jean Downes.* Genetic and social significance of differential fertility: articles by *H. F. Dorn, L. H. Snyder* and *G. Murphy.*

Monthly Labor Review—

December 1947—Changing size and composition of labor force.

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Quarterly Journal of Economics—

November 1947—The rôle of relative wage differences in international trade: *K. Forchheimer.* The rehabilitation of pure competition: *A. Nichols.* Union-management of welfare plans: *R. Rosenthal.* Discrimination under market interdependence: *Y. Maroni.* The emerging pattern of bilateralism: *J. Polk* and *G. Patterson.* Spanish prices in the nineteenth century: *J. Sardà.*

Review of Economic Statistics—

November 1947—Appraisals of Russian economic statistics: articles by *S. E. Harris, C. Clark, A. Gerschenkron, A. Baran, P. A. Bergson* and *A. Yugow.* Two interpretations of Keynesian economics: articles by *A. H. Hansen* and *A. F. Burns.* On mathematics for economists: *J. Marschak.* Wage structures: *Stanley Lebergott.*

CZECHOSLOVAKIA—

Statistický Obzor (Czech text, Russian, English and French summaries)—Vol. XXVII, Part 4—The new organization of statistics: *Frantisek Fajfr.* A picture of national economy: *O. V. Albrecht.* Testing of differences between relative frequencies: *V. Vlach.*

FRANCE—

Journal de la Société de Statistique de Paris—

September-October 1947—Quelques aspects statistiques de l'évolution bancaire en France: *C. Penglaou.* Mérites comparés des divers indices de correlation: *R. Féron.* Les destructions d'immeubles d'habitation et d'usines en France au cours de la guerre 1939–1945: *L. Flaus.*

November-December 1947—Conférences statistiques internationales (Washington). Evolution des statistiques relatives au travail et aux questions sociales depuis le début de 1945: *H. Lacroix.* Les espaces abstraits et leur utilité en statistique théorique et même en statistique appliquée: *M. Fréchet.* Variété: La statistique appliquée au contrôle des fabrications: *Gérard Pile.*

HOLLAND—

Statistica—

Vol. I, No. 4/5—Het begrip "universum" in de statistica: *Ir J. van Ettinger.* De kosten van levensonderhoud te 's-Gravenhage in December 1946: *A. J. M. Vermeulen.* De statistische kwaliteitscontrôle als economisch probleem, I: *W. Geiss.* Weersverwachting op lange termijn, II: *S. Œ. Visser.* Constructie van kansellipsen in een correlatiediagram: *Th. Hekker.* De bewerking van veldproeven volgens de methode van Knut Vik: *A. Stoffels.* Lijnvereffening met behulp van orthogonale polynomia: *E. van der Laan* and *J. G. W. Ignatius.* De betrouwbaaheid van controleurs: *W. H. Somermeijer.* De bepaling van de nauwkeurigheid waarmede metingen of beoordelingen worden verricht: *G. Posthumus.* Statistica, 2. Verdeling van kansen: *S. T. Bok.* Het quantitatieve verband tussen dosering en letaliteit bij proefdieren: *C. A. G. Nass.* Onderzoek naar de variaties in de bedragen waarvoor bij openbare aanbestedingen wordt ingeschreven: *J. J. van der Wal.*

ITALY—

Giornale degli Economisti e Annali di Economia—

May-August 1947—Considerazione sui "cicli chiusi" e sui "cicli aperti" dell'economia matematica: *G. Sensini.* Stabilizzazione: *B. Foa.* Gli indici iota di equilibrio monetario: *I. Gasparini.* L'economia dei prodotti tipo "utility": *A. N. de Neuman.* Generalitá su un nuovo metodo statistico per lo studio dei problemi della nutrizione: *L. Bruni.* Sulla valutazione probabilistica delle diversità fra costanti statistiche: *L. Faleschini.*

SWEDEN—

Ekonomisk Tidskrift—

Ekonomi och politik: Ekonomiska konjunkturer och politiska val i USA 1868–1944: *J. Akerman.* Några sympunkter på beräkningen av levnadskostnadsindex I Sverige: *C. E. Quensel.* Prisbildningsteorin och konsumtionsföreningarnas prispolitik: *A. P. Aizilnieks.*

INTERNATIONAL—

International Labour Review—

November-December 1947—The Swiss old-age and survivors' insurance scheme: *A. Saxer.* Manpower report of the Committee of European Economic Co-operation: Social conditions of transport workers in Germany.

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LIST OF ADDITIONS TO THE LIBRARY

Since the issue of Part II, 1947, the Society has received the publications enumerated below.

I.—OFFICIAL PUBLICATIONS

(a) United Kingdom

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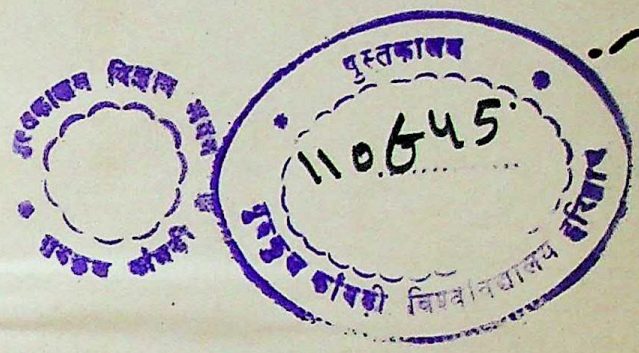

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